ELECTRONIC APPENDICES

Contents

APPENDIX A: RIPPLE TANK TEACHERS GUIDE

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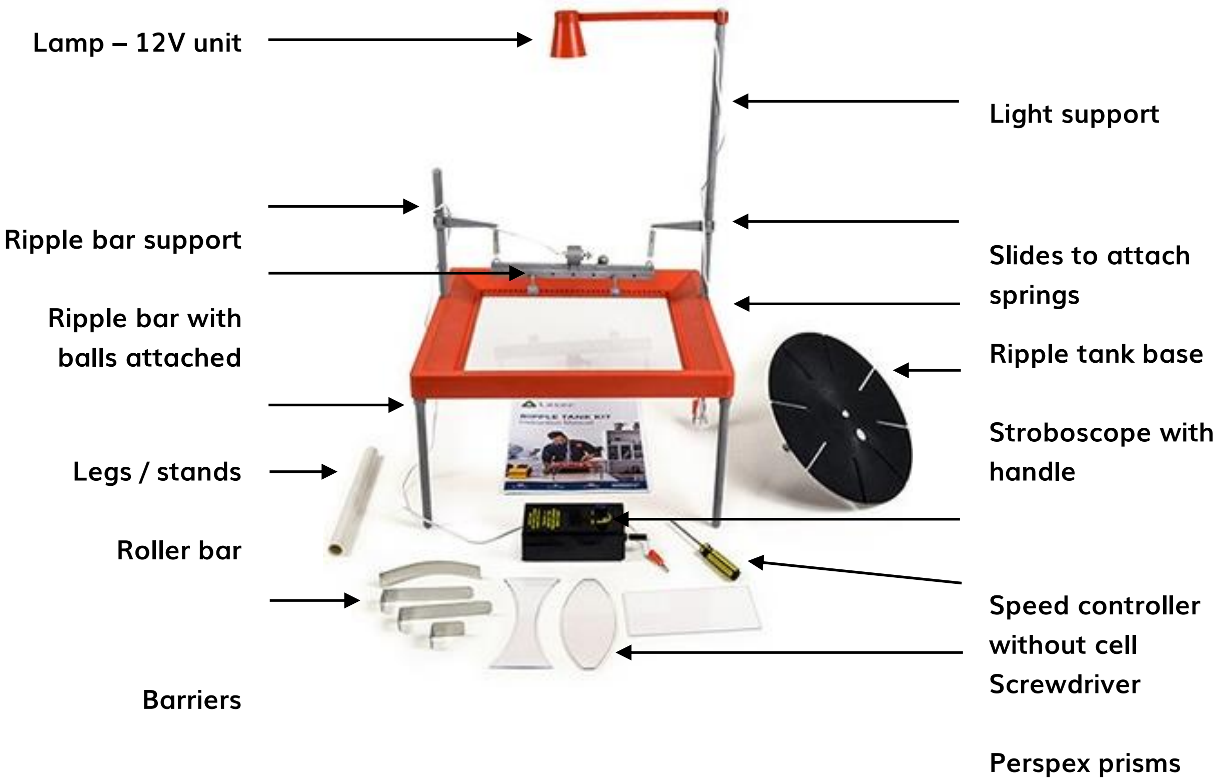
INTRODUCTION

A Ripple Tank is a shallow tank of water with a transparent base used in schools and colleges to demonstrate the basic principles of waves. It is a specialized form of a wave tank.

At last - a Ripple Tank that really works! This new ripple tank with its sloped plastic surrounds and revolutionary wave dampers, produces clear wave patterns without interfering wave reflections from the side. The bright low voltage halogen lamp illuminates the tank from the top so that light shines through the water enabling the wave patterns to be projected onto any white surface placed below the tank. These patterns are clearly visible, even without darkening the room.

All the basic properties of waves, including plain waves, reflection, refraction, interference and diffraction can be demonstrated.

ASSEMBLING THE RIPPLE TANK



1. Assemble the Ripple Tank as shown above. The base support legs and the support arms simply slide into the slots on the Ripple Tank base.
2. Link the springs onto the ripple bar and suspend the springs off the slides.
3. Place the Ripple Tank on a smooth, horizontal surface.
4. Pour water into the tank to a depth of about 5mm. The wave dampers on the perimeter of the tank must not be completely submerged.
5. Add a few drops of household detergents or dishwashing liquid to the water. This lowers the surface tension of the water, which results in better waves.
6. Adjust the position of the plastic slides so that the rippler bar just touches the surface of the water. Add the balls to the bar when needed.
7. Place a sheet of white paper or cardboard (A3 size or larger) on the surface immediately below the ripple tank.
8. Remove the base of the speed control and cell holder (held in place by 4 screws) and insert one 1.5V, type "D" cell in the holder. Use the screwdriver provided. Replace the base plate. Connect the conductor leads from the wave generator (rippler bar motor) to the terminals on the Speed Control and cell holder.
9. Connect the lamp to a suitable 12V power source. Adjust the position of the lamp so that it is suspended over the center of the tank.

GENERATIONS OF WAVES

A) HAND GENERATION

1. Place the white plastic roller bar in the tank, parallel and near one of the sides.

2. With two fingers resting on the bar, give it a short, single back and forth rolling movement. This gives it a single PULSE.

3. To produce a wave train, simply move your two fingers on the bar in short, rapid back and forth movements.

4. Drops of water from a medicine dropper or a steady stream of drops from a burette falling on the water in the tank produces very good circular wave patterns.

B) THE ELECTRICAL WAVE GENERATOR PLANE WAVES

1. Suspend the rippler bar with the motor from the horizontal support rod by means of the two springs provided.

2. Adjust the height of the bar, by moving the plastic hangars/slides on the side arms, so that the bar just touches the surface of the water across its whole length.

3. Connect the lead from the motor to the terminals on the Speed Control cell holder. Loop the conducting leads loosely over the support rod so that the rippler bar is free to vibrate on the suspension springs.

4. Turn the Speed Control knob until the motor just starts turning. By adjusting the setting on the Speed Control knob, you can produce waves of the desired frequency.

USING THE RIPPLE TANK TO STUDY THE PROPERTIES OF THE WAVES

Detailed description on the use of the ripple tank to investigate the properties of waves are given in most text books. The following notes merely highlight special aspects when using the Ripple Tank for these experiments.

1. REFLECTION

- Generate a set of plane waves in the Ripple tank using the electric or hand generator.
- Set up two solid barriers, placed end to end at 45° to the wave front. Now vary the angle and note the direction on the reflected waves in each case.
- Use the curved barrier to investigate a non-planar reflection.

2. REFRACTION

- Place the rectangular plastic sheet in the tank. The water should just cover the Sheet - if not, add a little more water.
- Generate plane waves. Rotate the sheet so that the waves strike the leading edge of the sheet, normally at different angles.
- You can also study the plane of waves in lenses by the convex and concave shaped plastic sheets in the kit.

3. DIFFRACTION

- Generate plane waves in the tank.
- Place the straight barriers all the way across the middle of the tank at right angles to the direction of propagation of the waves. Slide the two inner barriers over the outer two to create a wide gap at the center. Observe the wave pattern.
- Narrow the gap (slit) at the center step by step and observe the degree of diffraction in each case.

4. INTEREFERENCE

- Repeat the above procedure but insert the short metal barrier between the two Large barriers to create two gaps (double slit). Vary the size of the gaps by moving the outer two barriers and not the interference pattern in each case.
- Now raise the Rippler bar and bring the two spherical, plastic dippers into play. The distance between the dippers can be varied by rotating the arms of the dippers and by moving the dippers to other positions on the Rippler Bar.

MAKING CIRCULAR WAVES

1. Raise the rippler bar above the surface of the water by raising the plastic sides holding the horizontal support rod.

2. Rotate one of the spherical dippers on the rippler bar to point downwards. Adjust the height of the Rippler bar so that the dipper just touches the surface of the water.

3. Adjust the speed Control so that the dipper vibrates on the surface of the water at the desired frequency.

4. To produce a double set of circular waves (to study interference), rotate both dippers to point downwards.

USING THE STROBO-DISC

By rotating the strobo-disc at a critical speed while looking at moving waves through the slits of the disc, a standing wave pattern is observed.

1. Remove the screw from the disc handle and insert it through the hole in the center of the disc. Screw the handle back in place so that the disc rotates freely on the screw as axis.

2. Grip the handle in one hand. Hold the disc in front of your face with its face parallel to the tank. Now insert your index finger of the other hand into the hole in the disc and rotate the disc.

3. Look at the waves through the slits in the disc. By varying the speed of rotation, the waves will appear faster, slower or even stand still.

EXPERIMENT 1:
REFLECTION OF WATER WAVES IN A RIPPLE TANK

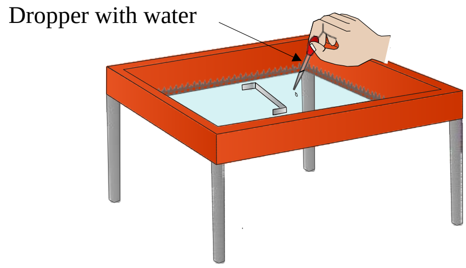
TO INVESTIGATE: How water waves behave when they strike a barrier

YOU WILL NEED:

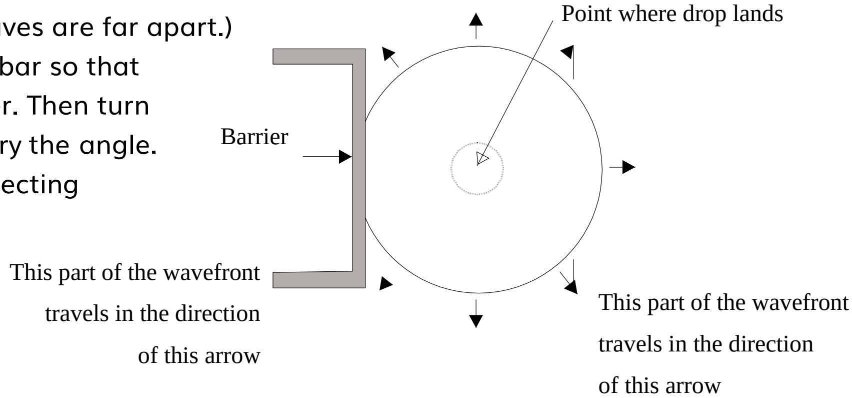
- A Ripple Tank and attachments
- A3 size white paper
- Electric Vibrator
- Water
- Dropper

WHAT TO DO:

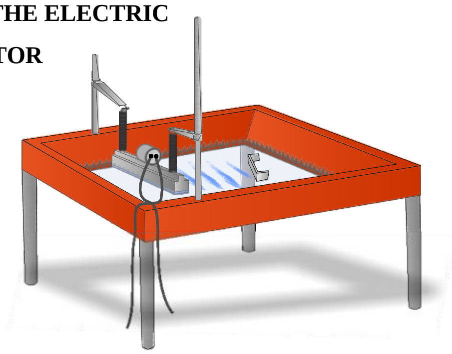
MAKING A WAVEFRONT WITH A DROPPER

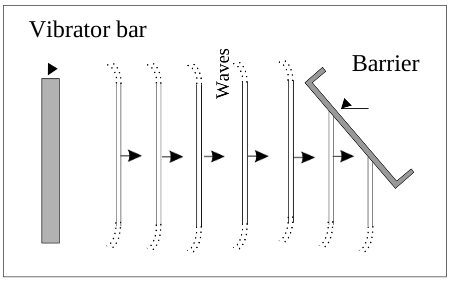


1. Fill the ripple tank to a depth of about 6mm with water
2. Place a straight barrier across the middle of the ripple tank.
3. Using a dropper, allow one drop of water to fall onto the surface of the water, so that it makes a circular wave.
4. Watch what happens when the wave strikes the barrier.
5. Now place the rippler bar at one end of the tank and roll it back and forth to make a series of pulses. (You can also set up the electric vibrator to make the waves. Let the vibrating arm just touch the surface of the water. Set the control on low so that the waves are far apart.)
6. First place the barrier parallel to the bar so that the waves reflect off a straight barrier. Then turn the barrier at an angle to the bar. Vary the angle.
7. Note what happens to the waves reflecting off the barrier in each case.



MAKING WAVES WITH THE ELECTRIC VIBRATOR





DRAW WHAT HAPPENS TO THE WAVES WHEN THEY STRIKE THE BARRIER

ASSESSMENT:

1. Draw the circular wavefronts from the drops when they strike the barrier and show what happens to them afterwards.
2. What happens to the straight wavefronts when they strike the barrier at an angle?
3. Is there any relationship between the angle that the wavefronts strike the barrier and the angle that the reflected waves travel from the barrier.
4. Look up the words incident wave and reflected wave in your textbook. Try to formulate a law of reflection from a flat surface.

EXPERIMENT 2:
REFRACTION OF WATER WAVES IN A RIPPLE TANK

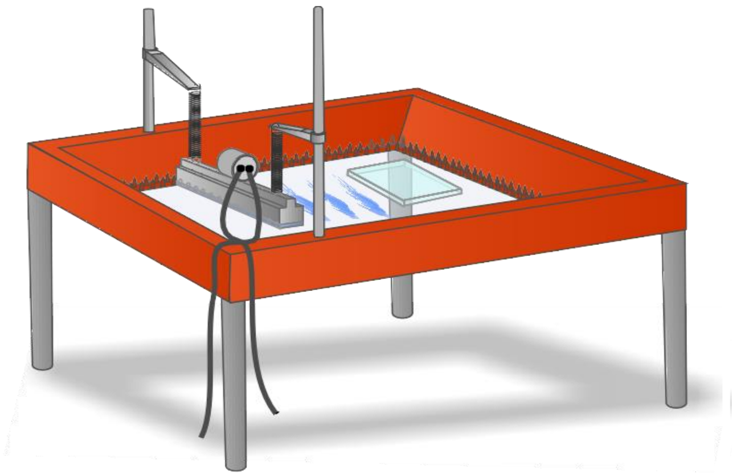
TO INVESTIGATE: What happens to water waves when they move through shallower water.

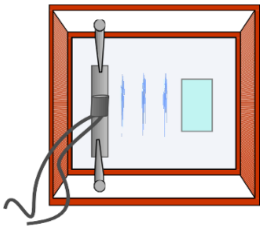
YOU WILL NEED:

- A Ripple Tank
- Water
- Electric Vibrator
- Perspex rectangular shape
- Rippler bar

WHAT TO DO:

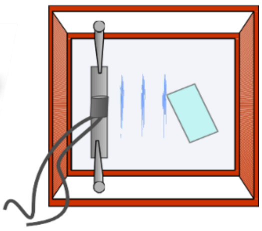
1. Place the rectangular perspex shape near the middle of the ripple tank, parallel to the rippler bar or electric vibrator.
2. Fill the ripple tank with water so that the water just covers the perspex shape.
3. Use the dropper and allow one drop of water fall onto the surface of the water so that it makes a wavefront. Watch what happens when the wave strikes the shallower water over the rectangular shape.
4. Now place the rippler bar at one end of the tank and roll it back and forth to make a series of pulses. (You can also set up the electric vibrator to make the waves. Let the vibrating arm just touch the surface of the water. Set it on a low setting so that the waves are far apart.)
5. Watch what happens when the waves move over the perspex shape.
6. Now turn the shape at an angle to the vibrating bar.
7. Note what happens to the direction of the waves and the speed of the waves when they move over the shape (shallower water).





TOP VIEW OF THE RIPPLE TANK KIT

Waves striking shallower water parallel to the leading edge



Waves striking shallower water at an angle

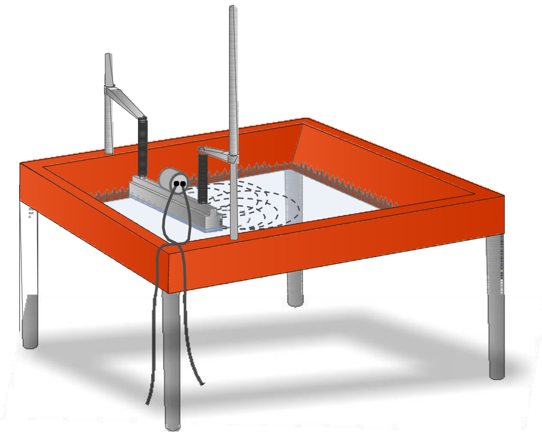
WHAT TO DO:

1. How does the speed of the wave change in shallower water?
2. What happens to the direction of the wave when it meets shallower water?
3. When the speed of the wave changes what happens to the shape of the wave?
4. Make labelled drawings to show the waves approaching the perspex shape and what happens to them when they pass over the shallower water
5. Look up the definition of refraction and relate this to what you saw in this investigation.

EXPERIMENT 3:
INTERFERENCE PATTERNS IN A RIPPLE TANK

TO INVESTIGATE: The interference of water waves in a Ripple tank

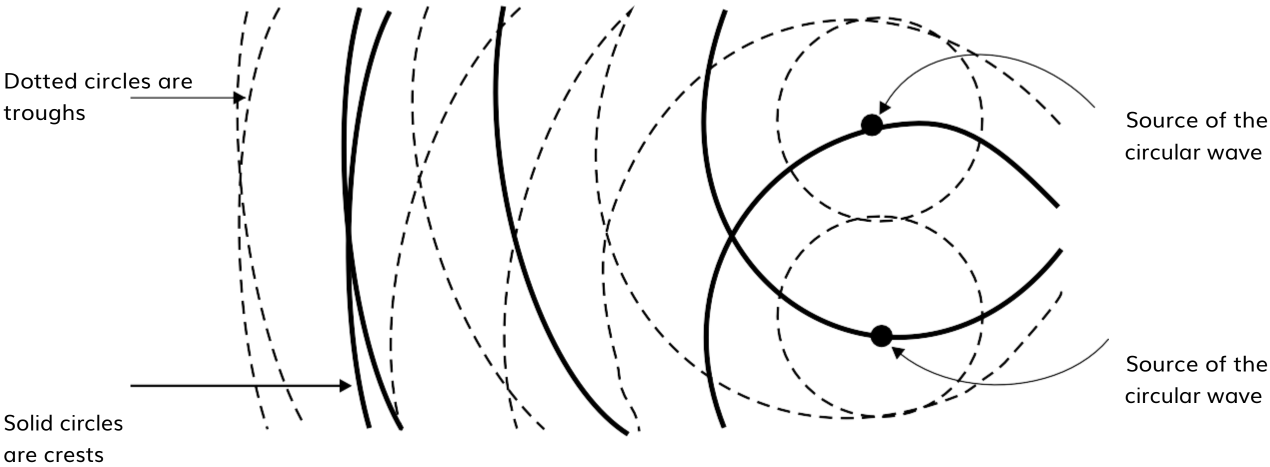
When waves collide with each other, they interfere. This interference can either be destructive when they cancel one another, or constructive when they reinforce each other. The diagram below shows the interference of waves.



YOU WILL NEED: A Ripple Tank Kit
A3 size White paper

WHAT TO DO:

1. Set up the Ripple Tank so that light shines through the tank onto some clean white paper below.
2. Adjust the two spherical spheres on the rippler bar to touch the water surface, so that circular waves are produced from two sources.
3. Observe and record what happens to the waves.
You will notice that nodal lines are produced.
These are lines that indicate zones of constructive interference.



4. Change the speed of the motor and see how this affects the wavelength of the waves produced.
5. Observe and record how the change in wavelength changes the number and nature of nodal lines produced
6. Try to work out a relationship between the number of nodal lines produced and the wavelength of the waves. You may want to measure the wavelength of the waves with a ruler on the paper under the ripple tank.
7. Count the number of nodal lines produced each time you change the wavelength.
8. You might like to use the table below.

WAVELENGTH (CM)	NO. NODAL LINES

I / MY PARTNER COULD DO THE FOLLOWING	CIRCLE THE SCORE YOU THINK YOU DESERVE			
Set up the Ripple Tank	1	2	3	4
Measure the wavelength and count the number of nodal lines accurately	1	2	3	4
Interpret the results of the experiment and develop a rule for how the number of nodal lines depend on the wavelength of the waves	1	2	3	4

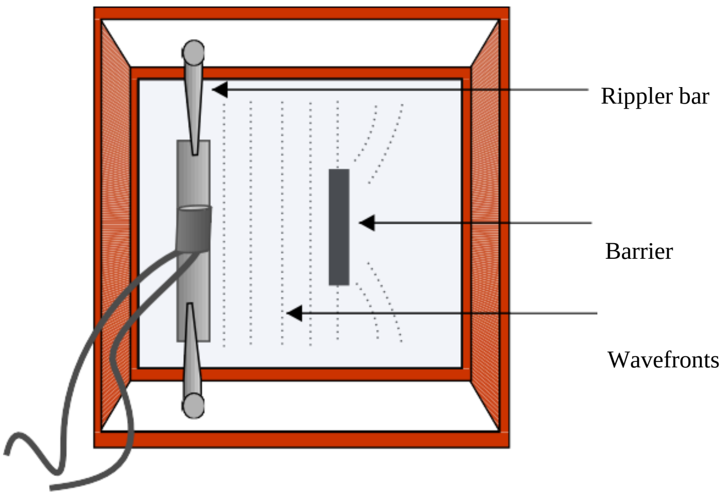
EXPERIMENT 4:
DIFFRACTION OF WATER WAVES IN A RIPPLE TANK

TO INVESTIGATE: Diffraction around an obstacle

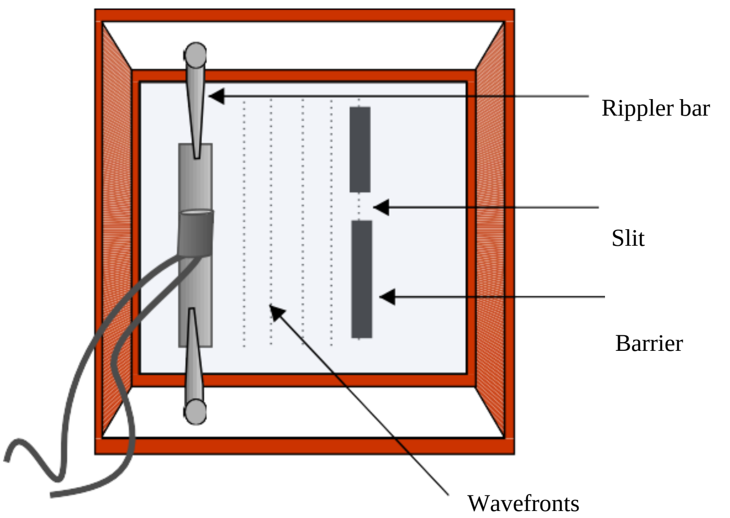
YOU WILL NEED: A Ripple Tank kit
A3 size paper

WHAT TO DO:

TOP VIEW OF THE RIPPLE TANK KIT



1. Set up the ripple tank so that the light shines through the tank onto some clean paper below.
2. Arrange the apparatus so that it produces straight waves from the rippler bar.
3. Place a barrier half way across the tank, parallel to the wave front.
4. Observe and record what happens to the waves.
5. Change the speed of the motor and see how this affects the wavelength of the waves produced.
6. Observe and record how the change in wavelength changes the diffraction of the waves.
7. Now place another barrier opposite the first barrier, so that the waves are made to pass through a slit of width *a* as shown in the diagram below.
8. Observe and record what happens to the waves.
9. Investigate the effect of changing the slit width on the degree of diffraction (remember to keep the wavelength the same.)
10. Investigate the effect of changing the wavelength on the degree of diffraction, while keeping the slit width the same.
11. Measure the wavelength and the slit width with a ruler on the shadows that are formed on the paper under the ripple tank. You will need to work out a way to measure the degree of diffraction through the slit.



12. You might like to use the table below.

SLIT WIDTH (CM)	WAVELENGTH (CM)	DEGREE OF DIFFRACTION

13. Now use the barriers to make two slits. What happens to the diffracted waves that interfere with each other when the waves are incident on a double slit? Write a short account of your observations and compare these to observations of previous experiments.

ASSESSMENT

I / MY PARTNER COULD DO THE FOLLOWING	CIRCLE THE SCORE YOU THINK YOU DESERVE			
Set up the Ripple Tank	1	2	3	4
Measure the wavelength and the slit width accurately	1	2	3	4
Record the data accurately in the table	1	2	3	4
Work out a way to measure the degree of diffraction	1	2	3	4
Interpret the results of the experiment and develop a rule for how the degree of diffraction depends on the wavelength and the slit width	1	2	3	4
Investigate the interference effect of two slits and write a comparison of this effect with that of previous experiments	1	2	3	4

APPENDIX B: TRANSCRIBED SCRIPT FOR THE SEMI-STRUCTURED PRE-INTERVIEW, JESSICA

INTERVIEWER: Okay, so I am with participant A doing the pre-semi structured interview. With gender female and we are in the age group between 18-25 and 26-35. Okay, so thank you very much. Firstly what are your qualifications?

INTERVIEWEE: So teaching qualifications. I have a PGCE from the University of Witwatersrand and I've got that in 2016 and then before that I have an Honours Degree in Geo Chemistry, so BSc. Honours in Geo Chemistry and then obviously BSc. General. So those are my qualifications in terms of tertiary. All at University of Witwatersrand.

INTERVIEWER: Awesome. Are you currently registered for any science studies?

INTERVIEWEE: No.

INTERVIEWER: Okay. Have you participated in any previous physical science training and if so, please elaborate?

INTERVIEWEE: I have gone to some ... well I have gone to the IEB conferences and often they do mention things there, but I wouldn't really call that so much as training because it's more like a general discussion to the group.

INTERVIEWER: Okay so you say it's more of a discussion.

INTERVIEWEE: Ja.

INTERVIEWER: It's not really making you do hands on physical practice?

INTERVIEWEE: Yes I agree with that.

INTERVIEWER: Perfect. So because it was more of a discussion have you found that type of training appropriate number one and helpful to you?

INTERVIEWEE: Okay well in that ... in those specific cases with the IEB conferences it is usually based at matric level where at the moment I am not a matric teacher. So sometimes it is a bit farther and more deeper into the science than what I actually do in class, but it still ... in a way it's nicer for me to know because obviously I can refresh on that stuff and get more experience in terms of different pracs, but in terms of me actually using it it is not always that useful.

INTERVIEWER: Okay so to date basically the experience of what you do as pracs in the classroom you haven't really attended training per say on that type of equipment.

INTERVIEWEE: Yeah not official. If anything, it is another teacher briefing me through it before hand, but I wouldn't call that official training. It's more like making sure I know what is going on.

INTERVIEWER: Perfect that's perfect. Okay, so how many years have you been employed as a teacher, just as a teacher as of the end of 2018?

INTERVIEWEE: Two years.

INTERVIEWER: And as of a physical science teacher.

INTERVIEWEE: Two years.

INTERVIEWER: Perfect. Okay, so now what I'm going to do is I'm going to read out to you different teaching styles. Listen to all of them there are three, four, five of them. Okay so then there are five of them and I'm going to read all five to you and then you just let me know which one best suits you.

INTERVIEWEE: Okay sure.

INTERVIEWER: So the first one and then remember there is no right or wrong answer. So the first is telling or lecturer, it is teacher-centred involving lengthily period of teacher lectures and students absorb and take notes. The second one is demonstration which is similar to lecture style but includes some multimedia presentations. Demonstration and activities that are done by the teacher only. Or hybrid blended which tailored teaching styles to the learners needs trying to please every type of learner and their different learning styles. Facilitator, which initiates students self-learning and helps learners to develop critical thinking. Allows learners to ask questions and find own answers through exploration and then a delegator which is guided discovery inspires students to reach a common goal and works with the learners.

INTERVIEWEE: Okay, so that one is a bit difficult because we at this school use a textbook that we've created. So often there will be times we were do go to using resources like videos, demonstrations and sometimes we just throw the kids into an experiment and expect them to figure it out. So it like ... I literally do all of that. Because there will be certain sections we were do need to go into more like detail as in like explaining how the history of the atom came about. So that unfortunately they can't really discover that much themselves. So there will be certain times where it is more lecture style but then there will also be certain times where it is more discovery and then there will be certain times where it is more question and answers. So it is kind of difficult to fit into one of those because I seem to touch between all of them depending on the topic and depending how we have decided to approach it.

INTERVIEWER: Brilliant. What you see as your teaching strengths?

INTERVIEWEE: Okay I think I'm confident, well I hope I'm confident, I believe I'm confident. I am quite ... I'm not the static teacher I like to move around and I like to continuously check with the kids. So I'm always going around and I go to the kids and say are we okay? Do we know what is going on? Is this working, is this not working, do you need help? I try and let the kids be more responsible for their learning in a way. So if they're struggling but they say they're fine I'm like are you sure and then if they say yes then I'm like okay, but then when we do discuss it I'll try and use their mistakes to try and help them realise that they weren't'. So I like that approach that I use. I don't know in terms of what other things I would call strengths ja.

INTERVIEWER: Absolutely fine. What areas do you feel are relatively weak in your training or training/teaching?

INTERVIEWEE: I will personally say that my PGCE was not very useful. It was more of a general knowledge thing. Because pretty much I'm here based on what I kind of figured beforehand. I didn't really get too much training in terms of science. My other subjects like I mean I did study in maths, that one was very decent, very insightful. We really unpacked a lot of information but with science it was not that case. So sometimes I feel like I might not have the complete depth of all the different things. One because I haven't done some of the topics since matric and then two because even if we did do the topic we might not necessarily have done it deeper than what we do it in class. So often I have to find that I need to go deeper usually by myself or I go to another teacher and ask them. So then that I would say is maybe probably my biggest weakness.

INTERVIEWER: Awesome. Currently what do you do to increase your own general content knowledge?

INTERVIEWEE: So if it is a thing that's weak then I will usually go to you tube videos or I'll go and look up papers and see if I can find information, refer to textbooks to see how other sources have chosen to approach it because I find that is quite useful rather than diving in you might find that a textbook has decided to take it this way or a person, because also I speak to other teachers, they decide to approach it that way and I decide based on what I think the class is able to deal with which is the best method for it. So usually I try and get a variety of sources and then go with the best way. Luckily I do have enough classes where I can repeat it and change it and usually that helps. Maybe not this year, but for the next year.

INTERVIEWER: For sure, for sure. Awesome okay. In what ways would you define science teaching?

INTERVIEWEE: In what ways? I would define it as practical. I would say it's relevant though sometimes not obviously relevant. So like there will be cases where we are doing something that's relevant but a nine ... a grade nine learner might not realise how relevant it is. Because they don't realise how it's literally used in everyday life. I would think, I think it is quite a necessary teaching and I think it's ... it gives skills that you need. So it also ... it gives you skills that you won't need just for science but for other subjects as well.

INTERVIEWER: Perfect what types of activities or support events would help you grow in science knowledge knowing that you are a young teacher? What type of activities or support events would you feel helpful?

INTERVIEWEE: I would really appreciate if there were options or opportunities to actual go through and unpack the sections. So what are the most common misconceptions and how do we fix those? So how do ... so like instead of me trying to figure out like literally figuring it out in class. I can say that when you are doing circuits this is a big misconception. This is a big misconception and this is how we can prevent that misconception, because then in that way my teaching can be more focused on well this is how we go deeper rather than trying to fix all the little misconceptions that arise that I might not be aware of and now having to try and fix those.

INTERVIEWER: Brilliant. Perfect. How do you think learners learn science?

INTERVIEWEE: I think it depends on the learner. Some get it; they don't even have to think it seems they just click. Where ... those are sometimes brilliant, they easy where some kids it depends. So if they are struggling with maths science can be very challenging. Because often they overlap. Sometimes the English is bad and because it is an English median school the questions can be a problem for them. Not that they don't know the science but the actual questions and the way we ask it can be an issue. Especially also with IEB trying to get them to think more. Sometimes that can be a problem and then some kids they get it but they need to give a lot more like effort into it. They'll try it, they won't get it right every single time but you can see that every time they try it they get it better. So it completely depends on the kids. As I say some get it and some only get it if you explain in a different way, so I don't know it's ... I can't say generally.

INTERVIEWER: Perfect, no it's perfect. That's exactly what we want. So what do you see as important to do or have to teach physical science effectively.

INTERVIEWEE: I think it is important that you ensure that it is relatable and that it is not as difficult as everybody thinks, because people think science just like maths, has got this stigma of being really difficult. It is actually not difficult it is rather logical and it is trying to break down that wall of the difficulty I think is very necessary. So you need to try and keep it simple but obviously still teach it and you need to do it in a way that they understand it and can relate to it and they are enthused by it. So obviously don't just keep it into what you need to cover for the curriculum, try and show how it can go into their futures. I think that's really important.

INTERVIEWER: Brilliant. When do your students learn science best?

INTERVIEWEE: Okay, so that is also ... I think because how we approach this is we have grade 8s and 9s and it's very hands on. So it is very like observation, conclusion. So if this is what we do this is what we do this is what we'll get. So it is pretty much all the fundamentals. So we don't really follow CAPS. We go through all the fundamentals. It is more like getting the main ideas usually it is the stuff that relates to matric. So we will make sure that they get the real early fundamentals say of circuits and start that in grade 8 so by the time it's matric they really do have a good understanding. So the thing ... grade 8 and grade 9 is very hands on, it's very like discovery, intuition, getting the right messages. Trying to connect those or make those connections, but in obviously grade 10, 11 and 12 when they need to do the proper sciences and more like the actual proving things and calculating and getting significant and action valuable data that is more apparent in the higher grades where in the lower grades it's not. But in the higher grades because they've got those fundamentals that is really no longer of importance. So in terms of the fundamentals of the earlier grades because we focus a lot on that where as in the higher grades it is more like well now that you know the fundamentals let's prove that they true.

INTERVIEWER: Brilliant. Perfect. Do you believe in using hands on apparatus during the lesson and if so elaborate on how often within a week you conduct such lessons?

INTERVIEWEE: Okay again that is a bit difficult because with our cycle through the lessons we only see our juniors five times in two weeks. So I'm not going to necessarily talk about a week here because some weeks we only see some classes once or twice. Where if we see that they are five times within two weeks usually in that five times, well for the juniors five times cycle, we will at least have the prac a week and if we can we will let them do as many hands on experiments as possible. Obviously there is some that we can't, one because of lack of equipment or it's quite dangerous then obviously we will take those over but we are as much as they need to play with it as they can. So with the seniors it is a lot more frequently because we see them 10 times. So double the amount, so with that there is a lot more. And obviously a lot more pracs, at least two a week or two a cycle and then those will then have a lot more depth to them and a lot more actual skills. So by the time they get to grade 10 they really should be confident in doing most experiments because they had been playing with the stuff in grade 8 and grade 9.

INTERVIEWER: Lovely, perfect and how long is your cycle?

INTERVIEWEE: A two week cycle.

INTERVIEWER: Okay a two week cycle. Brilliant. So like you say with the grade 10s specifically which is what this is focussing on, you would say roughly within a cycle it's twice.

INTERVIEWEE: Ja.

INTERVIEWER: Of doing hands on.

INTERVIEWEE: Yes, some weeks it obviously doesn't work out that way but I would say on average we do about two a cycle.

INTERVIEWER: Perfect, brilliant. Then during that allocated prac time that you talk of when you look at it in ... we can discuss it as a percentage wise or you can just discuss it. I'm just using percentage so that you understand what it is. We're looking at a lesson of 100%. What percent of a lesson would you use simulations, apparatus and textbook images?

INTERVIEWEE: Okay is this specifically practicals?

INTERVIEWER: Practicals yes.

INTERVIEWEE: Okay usually in the practicals its proper experiments. So we will give them the breakdown. If we do need to show simulation that won't necessarily be done in the pracs that is usually involved in the actual theory. Kind of promotion like the setup for the prac, the prep or afterwards. Especially if we didn't get an ideal result often that happens.

INTERVIEWER: Okay.

INTERVIEWEE: So usually if that happens that we don't get a nice ideal result then we will show them the ideal based on a simulation. Sometimes we do it before but usually we try and let them discovery it before they do the simulation and it shows them. So in the actual pracs it is more ... we make sure that they understand the method. Obviously they get given that all beforehand so that we do encourage them to read it, but as kids do they don't. So usually we have to go through that with them and then we give them the lesson to run with it and then at that time it's as if you want to go back to the teaching styles it's more facilitator. So we are just checking that they are okay, checking that they are on the right page. That they are not wasting time or they're not doing something completely wrong. So they just are going through the process as they should.

INTERVIEWER: Brilliant. So basically you would ... the way you say you would do the simulation at textbook content during the theory things, normally before a practical and the prac is just prac.

INTERVIEWEE: Yes.

INTERVIEWER: Brilliant. Okay, so what challenges do you have in the classroom teaching physical sciences?

INTERVIEWEE: In the lower grades we are fully aware that not all of them want to take science and some of them I hate to say it but they not capable of taking science because of the limits that they find with Maths and English. So especially Maths, English is not so much. But especially maths if they really struggle with Maths they can really struggle with some of the science things and it's not necessarily the science theory itself but it's actually doing things like planting graphs and calculations and stuff like that and that is what really lets them down. So then they get very de-motivated because their marks obviously a lot of the percentage of it can be due to calculations and graphs and analysis and stuff like that and then they get a bad result and then they lose interest. So I said the biggest challenge is the fact that it is perceived difficult as a difficult subject and sometimes it is reinforced if they struggle with maths because of the fact that it is so linked with maths. So that is a challenge I would say, probably the biggest challenge. Otherwise it's the attitude, so if they've decided they don't want to do science then they completely disconnect especially near the end of grade 9 when they've made their subject choices. They have decided they don't want to then they disconnect and it's very difficult to get them to reengage if they decided I'm not going to pay attention because I don't need this in my future.

INTERVIEWER: Of course.

INTERVIEWEE: Ja.

INTERVIEWER: Then in your senior years what do you find the challenges that you have then with teaching physical sciences?

INTERVIEWEE: Okay so in my senior classes, my senior is limited by grade 10 because I only go up to grade 10. So I would say with the seniors again attitude can be a big issue. So if they just ... some of the kids believe that they are brilliant and then don't put a lot of effort in and then they get a shock in the cycle test or a test because they perceive it to sometimes be easier than what it is. So they answered the questions terribly because they think we're asking one thing and then they not. Another thing I think again maths is the issue, so even if they are okay in maths and they do take it up into the higher grades they struggle the whole way. So we do have some kids that really struggle the whole way through and literally from grade 8, from grade 10 all the way up to matric and this is not necessarily me but I have heard from the other senior teacher that they really are putting a lot of effort into the kids that are struggling who are not always necessarily returning the effort. One because maybe they can't in terms of academics and then two maybe because they're not interested and their parents are forcing them into the subject because obviously it is a nice subject for university and then as a result a lot of energy is spent on those kids who usually ... it's probably in their best interest to not take the science. So that is probably the biggest challenge higher up, everybody wants to take it, they can't always take it and their attitude is not conducive to them taking it.

INTERVIEWER: Perfect. Okay, so we have discussed that the school mainly follows IEB. So when you look at your IEB and the SAG document, the subject assignment guidelines as well as the CAPS because they are sort of combined do you conduct all the experiments specified by the curriculum?

INTERVIEWEE: So with ... we don't ... so as I've already mentioned the juniors we don't really follow SAGs, we don't really follow CAPS. We kind of give them what they need and especially if they are going to take science in grade 10, 11 and 12 what they'll need to make sure that they can complete the topics as best. We do try and do extra topics that are not covered, like for instance waves isn't a matric subject but we still do waves because we feel it's necessary and it's important for them to know. Also pressure is not necessarily covered in matric but they need an understanding of pressure in order to survive. So when they get into the higher grades we start sticking more to the SAG. So for instance our 11s and 12s, they do pretty much matric and grade 11 in the two years. Why I'm saying that they literally cover grade 11 and grade 12 organic chemistry in one year.

INTERVIEWER: Okay.

INTERVIEWEE: And then all the circuits in one year. So it's ... they say it's two years ... over two courses, two years but it's not split. So they will do circuits all at once and that is set up in the exact same order as the SAGs are. So they will be following the SAGs and with regards to the experiments, which is what you were saying, that we do do the ones prescribed but if they feel that there are other ones that better explain it we do swop them out. Obviously if there is certain ones that we need to do then we will do those but because of the opportunity of alternative tasks and stuff like that those usually end up being pracs which aren't necessarily focused on SAGs.

INTERVIEWER: Perfect. Have you felt that you have always had the correct resources to teach physical sciences?

INTERVIEWEE: Okay so that will go back to the PGCE. To be perfectly honest I think I could have had a lot more background given into the actual teaching of it. I do feel that my PGCE training was quite lacking but however I did go to a fairly good school, I considered to be a fairly good school so I feel that because it was IEB and because I was taught very well that obviously has helped a lot. So my background I think I could have had a lot more in terms of the actual teaching style where my understanding and applications of the topics also with my degree being chemistry and physics as well, because physics was incorporated I did, I do understand the concepts it's just I wish I could have given ... got given more information about actually how to effectively teach it.

INTERVIEWER: Awesome. Perfect and then in your school environment currently teaching as you mentioned you mainly teach in the senior phases you teach grade 10. Have you had the resources that you needed to teach physical science grade 10?

INTERVIEWEE: Yes, ja. All the textbooks are given and we are involved in making and contributing to it so the current textbook, the grade 10 textbook that we using I've been involved in helping it and improving it because it's never perfect so it's continuously being adapted continuously being changed. That is all provided before hand so obviously my first year I didn't really have much to contribute but obviously once I've run through it I now know exactly what is going through ... I knew exactly how they would like us to approach it. Even though we can choose not to. So the approach that we can take and then with that I've had all the resources. It would have been nice as I said to have a little bit more depth on the subject but the resources in terms of what to teach with was fine.

INTERVIEWER: Awesome and then you have touched on this a bit, but do you see waves as an important topic within the curriculum?

INTERVIEWEE: Okay, so we believe that it is and I agree and I agree that it is an important topic because it is literally all around us. We see it in everyday life and its useful information. So for instance how does your radio work? Well you don't know that unless you do waves and I mean some of these kids yes they might not go into to the actual science of waves but if they want to do stuff like anything with sound, anything with water, even with air, air can sometimes behave like a wave. You need to understand those basics so we find that it is very important even though it's not really considered a matric subject. So that is why it is still in our syllabus. We still teach it, because we find that it's important even though it's been taken out.

INTERVIEWER: Awesome. Then currently teaching grade 10 what resources do you usually use to teach and illustrate waves? This doesn't mean like ... it can be physical and non-physical, just in general.

INTERVIEWEE: So we have waves, well not waves, we have light boxes. So a lot of the properties like reflection, refraction, diffraction, a lot of that stuff can be illustrated using the light. So we try and use those as much as possible but we are limited because we only have five working light boxes and when you have classes of 25, which is not big. I know it's not big but it's a bit difficult to try and get each kid to actual make meaning and go into the real understanding and play with it when they have to share it with five other kids. So often with the way we teach waves is very hands on, so we teach, we discuss what reflection is. Talk about what they understand about it and then throw them into it. So saying here is a mirror play. What can we learn about it? What do we notice about it? If we put a piece of paper on this side we can see the image, is there relationship with how far the image is far away? So for waves particularly it is very hands on. The kids are always with the wave boxes. If not, the wave it is the ripple tank although that has its big flaws I find. It is very difficult sometimes to see the actual waves on the ripple tank because of various things and there is also a lot of interference. So I find more with the lights it is easier to see that but obviously the ripple tank is nice because you can also see the actual crests and troughs where with light you can't. So we use both.

INTERVIEWER: Awesome. Perfect and then grade 10, we looking at grade 10. What sub-topics or concepts do you consider to be key in the topic of waves? So just as a list.

INTERVIEWEE: So I personally I like the normal waves. I mean you need the wave breakdown. So you need to know all the terminology, amplitude, frequency, crest, trough or the working out the wave equation, speed and all of that. I obviously think all that is very important. You need to obviously need to know the frequency period, conversion, which is what we usually do. In terms of the actual properties of the waves and how they behave I do believe that reflection and refraction is important because that is mostly what they're going to be used to. So they'll see that in real life where something may be like de-fraction, they are not necessarily aware of it so they don't really know too much about it. So if we ... usually if anything that is the one we do leave out if we running out of time. As usually waves is done at the end of the year. Well the last two years it has been done at the end.

INTERVIEWER: Okay.

INTERVIEWEE: So if there is a time issue we usually leave out diffraction because in terms of them actually really seeing it used is not so applicable to their lives where reflection and refraction are. Interference we usually do teach and they usually get that quite nicely. I think that's a good part. We don't do lenses, we don't really do stuff like that again because it is not really needed so it is stressed in too much with the maths.

INTERVIEWER: Perfect. Right, so would you tell me about your usual lesson plan and tell me how you would carry out the lesson to teach wavelength frequency and period?

INTERVIEWEE: Okay so I can tell you how we usually approach this. Usually we take out a slinky and we play with the slinky and we see okay well if you move a slinky say one person holds one end and one person moves the other end and they move and we talk about different things. Like we can see the wave. Okay for me it helps because especially with the kids I did teach some of them geography which we did actually go through waves in like the actual water waves real life so a lot of the stuff came out there as well. So that is quite a nice way for me to relate the two but obviously if you don't do geography you wouldn't know that. So we try and ... I try and make it as real as possible so show them slinky waves, show them the water waves and then say okay but now we're going to talk about waves, how do we talk about it? So usually then they say we have the crest of a wave or the peak of a wave and that is usually the terminology and then we show them normal terminology so then we start introducing and talk about one wave cycle then we can talk about the length of how big it is verses how small it is. So ja that is usually how we approach it. So it is more like we see if they can come up with some of the words themselves. Obviously some of the words they will never get like amplitude, like the maybe the frequency they could get but they really wouldn't relate it to as it is exactly how it is defined. So we try let them, make them come up with some of the words. We try and get them to relate to the words and then obviously we then draw the diagram that everybody knows with the fully labels and all of that.

INTERVIEWER: Perfect. So you do more the introducing of terminology, get them involved guessing and then you show them the diagrams normally and then you do the practicals after that.

INTERVIEWEE: Yes.

INTERVIEWER: Brilliant.

INTERVIEWEE: And we teach ... so usually before the practicals on reflection and refraction and all of that we teach them how to work out the speed. How to work out the amplitude to get them familiar with working out if they need to. Like frequency and period and all of those. So they are familiar with those words before we start going into the frequency is going to change when this happens and the amplitude is going to change when that happens.

INTERVIEWER: Perfect. Okay and then exactly the same but now teaching the superposition.

INTERVIEWEE: Okay so with the constructive interference usually it is a very short section. Because again it's usually done at the end. So this term is different because obviously we're doing it at the beginning of the year so we have a smidge more time. So with the superposition we usually do that again with the slinky however I will say that it is a bit difficult to see the super position because there ... it is not exactly one always making nice pulse. It does have the bit of interference that comes through. So usually with the superposition we show it on slinky, we show it on a like a string or a rope and then we go to a simulation and show exactly the actual things behind it. Like the peak combine or they destroy or whatever happens that way. So we try make it like I say experimenty but then also make sure that they understand the big concepts behind it.

INTERVIEWER: Perfect. Right almost there. So what do you expect students would have difficulties in when learning about wavelength?

INTERVIEWEE: Well it is confusing because it can be measured anywhere. So you can measure it from crest to crest or trough to trough. Or from mid-point to mid-point, anywhere along the wave. So for them I think it's quite confusing the fact that there is no strict set rule for it and it can literally apply at any point along the wave as long as they consecutive. So I think that can be difficult and also I find especially if we have say five cycles, we find five cycles in five metres they think wavelength is the full five metres. Not the individual one meter so they do get confused with the actual full length of cycles versus the actual individual wave.

INTERVIEWER: Absolutely. Brilliant, ok so same things. What difficulties do you think learners have with frequency?

INTERVIEWEE: They confuse it with period. The biggest mistake, they get them confused.

INTERVIEWER: Brilliant because that is the next one. What difficulty do they have with period?

INTERVIEWEE: Ja so then it's the other way round.

INTERVIEWER: Yes, perfect.

INTERVIEWEE: They struggle to calculate it. So sometimes as I say ...

INTERVIEWER: Which one?

INTERVIEWEE: Both of them.

INTERVIEWER: Oh.

INTERVIEWEE: So they usually end up confusing them. So they know how to convert from frequency to period but they struggle to say okay well if we say five waves instead of seconds they struggle to work out the actual period and if they do end up working it out and they get it correct fantastic, but a lot of them end up working out ... or working that out, the period out and calling it frequency and then inverting it and then it gets a bit ugly later on. So they do struggle with like the word sentence I want to say. Getting that into what we actually asking for and then they overcomplicate their lives by trying to calculate something they're not supposed to.

INTERVIEWER: Brilliant and then what difficulties do they have learning about superposition?

INTERVIEWEE: They struggle to see how they combine. It is easy when it's peak and peak, to see how the peaks have combined but if it's part of wave and another part of a wave then they're like what. Because it is very easy obviously if your peak is two blocks on your simulation high or whatever on your ruler high. It's difficult ... so if the peaks are two blocks and two blocks you see how they become four blocks. But halfway up the wave it's one and 1.6 blocks and the other one is 3.2 blocks or whatever it is it is very difficult for them to realise that they actual are combining. So that I think is probably the most challenging part.

INTERVIEWER: Awesome. Now very similar but we're talking about misconceptions. Are you aware of any misconceptions with regards to wavelength and it's interesting because earlier you did mention how you would like training on actually getting misconceptions. So this is just reiterating.

INTERVIEWEE: Yes, yes. So ...

INTERVIEWER: Do you know currently of any misconceptions with wavelengths?

INTERVIEWEE: Okay so I would guess based on what I've figured out that they struggle as I said really with the distance so that they struggle with it being the full distance of the wavelength and one wave cycle, but also because the terms are quite confusing. So you can say there is a wave, so a wave ... some of the questions the way that they've asked it and it can ... I realise it can be confusing. You don't know if they're talking about the whole wave or a wave cycle, so that I find can confuse them. Otherwise I'm not really ... I don't really want to guess because I'm not really too sure. I found this section easy at school. So I was not someone who really believed to have misconceptions.

INTERVIEWER: Awesome and then the misconceptions that you currently know about frequency.

INTERVIEWEE: The frequency I would say that they ... again it's the understanding. So, I find that would be the most challenging thing for them and because of that misunderstanding of it then that is what leads them to confusing it with frequency. I mean not frequency, period. So I would say the actual wording probably leads to misunderstanding which leads to the confusion.

INTERVIEWER: And when you say wording, it's like the definition.

INTERVIEWEE: Yes because they're so similar it's like frequency how long it takes ... or how many ways to pass a point in one second. Where the other one is how long it takes for one wave to pass. Both of them mention one of something and both of them are talking about how many or how long so it's like ... they are very similar in their definition so if you don't really know them and you not really using them often. Obviously we as teachers do because we have to teach it every year then it's quite confusing to remember which one is which.

INTERVIEWER: Brilliant and then again misconceptions about superposition.

INTERVIEWEE: I think again it would be a guess, I believe that they struggle and they get confused again with the sides. They don't really understand why it cancels out. I think that's probably a big issue. Like why it will cancel out and appear on the other side. That I feel would probably be the biggest misconception. They believe that it wouldn't do that. That it would just cancel out and not start again.

INTERVIEWER: Awesome. Perfect. Okay, so that concludes the pre-interview. Thank you very much.

APPENDIX C: TRANSCRIBED SCRIPT FOR THE SEMI-STRUCTURED PRE-INTERVIEW, TSHUMA

<u>INTERVIEWER</u>: Okay dokie so today is the 12th of February and I'm with participate C. Thank you very much.

<u>INTERVIEWEE</u>: Thank you.

<u>INTERVIEWER</u>: And we're about to start the pre-semi structured interview. So participant C please tell me what age group are you in? Are you between 26-35, 36-45 or 45-60?

<u>INTERVIEWEE</u>: 36-45.

<u>INTERVIEWER</u>: Thank you and your gender is male.

<u>INTERVIEWEE</u>: Yes.

<u>INTERVIEWER</u>: Can you tell me your qualifications?

<u>INTERVIEWEE</u>: Okay. One for education, that is the diploma in teacher's education and the other one psychology.

<u>INTERVIEWER</u>: Lovely and where did you get those qualifications?

<u>INTERVIEWEE</u>: The first one is the University of Zimbabwe, the other one is Unisa.

<u>INTERVIEWER</u>: Lovely and what year did you obtain your psychology?

<u>INTERVIEWEE</u>: Psychology is 2018, last year.

<u>INTERVIEWER</u>: Lovely and when did your teachers one?

<u>INTERVIEWEE</u>: 2000.

<u>INTERVIEWER</u>: 2000.

<u>INTERVIEWEE</u>: Yes 2000.

<u>INTERVIEWER</u>: Perfect. What were your majors in your teaching one?

<u>INTERVIEWEE</u>: Teaching chemistry, biology and physics. We call it triple major.

<u>INTERVIEWER</u>: Okay are you currently registered for any science studies at the moment?

<u>INTERVIEWEE</u>: Not yet.

<u>INTERVIEWER</u>: Have you participated in any previous physical science training and if you have elaborated, tell me about it?

<u>INTERVIEWEE</u>: I think I have done a lot with our districts, with our Sc-Bono, we always go there for outdoor education and the workshop development. So I ... it's a lot of them. On chemistry content, physicist content, we always do developments for

chemistry and physics.
INTERVIEWER: Lovely and how long ago was your recent training?
INTERVIEWEE: The last year 2018, whats it called, at beachwood or something.
INTERVIEWER: Okay good and when you have these trainings is it like a lecture where you sit and they tell you the content or is it hands on.
INTERVIEWEE: First, normally what they do, they demonstrate us to how to handle the content. From there as a group we work on something and then we go and present on the ... to a panel.
INTERVIEWER: So you as a group would be given apparatus.
INTERVIEWEE: Yes.
INTERVIEWER: You would then work on it.
INTERVIEWEE: Work on it like every time we've got these prescribed experiment. So every time when we have to do them, we do them as teachers, but then we demonstrate to others on what we have been given as a task to help them. Like recently was esterification, we're doing esterification different types so going to present esterification to a group of teachers.
INTERVIEWER: And at this training is it on one topic or is it on many topics?
INTERVIEWEE: It depends. It's going to be like one concept this week and the another week it's another concept.
INTERVIEWER: Okay lovely and who carries out this training that you're talking about?
INTERVIEWEE: For our district a facilitator will identify teachers, but it is a sponsored workshop, but basically it is our district that will say school should go there. Then again on my part I've got another thing that I get from what you call Sci-Bono. Sci-Bono it's an NGO. So I am being trained to teach learners that are disadvantaged, also underperforming in public schools.
INTERVIEWER: Lovely and is that you that has decided to go for that Sci-Bono training, is it you that decided to sign up for it?
INTERVIEWEE: Sci-Bono training, they train us to help those other learners who didn't get results, matric results. So handpicked based on merit. You this teacher so much results and with average teachers above 50 or who didn't pass 100% then they ask us to go now to help in other schools. These schools who are underperforming.
INTERVIEWER: Wow.
INTERVIEWEE: So I am not volunteering we are being handpicked.

INTERVIEWER: Which is an accreditation so that's amazing.

INTERVIEWEE: Yes that's accreditation yes.

INTERVIEWER: Well done. Okay, so do you find these trainings, not the Sci-Bono ones, the ones that are organised by your district, are they helpful?

INTERVIEWEE: A lot. A lot. I'm teaching is evolving is what I can say because now with the new methods, these people will tell us exactly now how to approach certain topics to the learners. Because most of them again are the examiners. So when you come you come here changed because you know how to target the questions for the exams. Especially Grade 12.

INTERVIEWER: Lovely. Now how many years have you been employed as a teacher by the end of 2018?

INTERVIEWEE: I started teaching ... do you mean in South Africa or ...?

INTERVIEWER: As a whole.

INTERVIEWEE: I started teaching 1998. So that means it's close to 20 years.

INTERVIEWER: Lovely and then how many years have you been teaching physical sciences by the end of 2018?

INTERVIEWEE: 15 years.

INTERVIEWER: Lovely. Now what I'm going to do is I'm going to read out to you different teaching techniques. I'm going to read them to you and then you can tell me which you identify with okay.

INTERVIEWEE: Okay, its fine.

INTERVIEWER: So the first one is telling and lecturer, where the teacher ... it's teacher-centred involving lengthily periods of teacher lecturers, students absorb and take notes. The second one is demonstration. Similar to lecture style but includes some multimedia presentations, demonstrations and activities that are done by the teacher only. Hybrid or blended is where it's tailored teaching styles to the learners needs, trying to please every type of learner and their different learning styles. Facilitator, where it initiates student self-learning and helps learners to develop critical thinking, allows learners to ask questions and find own answers through exploration. And lastly delegator, a guided discovery inspires students to reach a common goal and works with the learners.

INTERVIEWEE: I think ...B…. can I chose only one?

INTERVIEWER: No you can tell me what you feel you are.

INTERVIEWEE: Okay mostly I think I'm on B and it says similar to lectures but includes some multimedia presentation, demonstration and things that are done by the teacher only, no. D, I would say facilitator. I was thinking on B, but it's only done by teacher only as done by demonstration. But I think I qualify to D.

INTERVIEWER: So you do demonstrations but you decided to change your mind on B because you don't just do the demonstrations you allow the learners to do it.

INTERVIEWEE: Yes to do what we call it, to improve on their skills, psycho motor skills.

INTERVIEWER: Lovely. What do you see as your teaching strengths?

INTERVIEWEE: I didn't get the question per say. Like in the content or in the subject?

INTERVIEWER: So when you are in your classroom what are your strengths? What do you know you do well?

INTERVIEWEE: I just I can say I'm good in presentation of the lesson honestly that is what I'm good at. Then at delivering content I'm very, very good. That I know, I'm confident when I'm in class. I think that is my strength. Content wise I think I'm fine especially in chemistry. I'm very competent and strong.

INTERVIEWER: Good and what areas do you feel are relatively weak in your teaching?

INTERVIEWEE: What can I say?

INTERVIEWER: In what ways would you like to improve yourself?

INTERVIEWEE: Myself. I think I have had my learners say mostly I'm too fast. So what I think I need to slow it down. Because at times I get carried away. When I'm in class I just enjoy my teachings and I move fast. So I think I need to improve on my pace on slowing down and then to their needs per say. So I think I need to slow it down because I hear that a lot.

INTERVIEWER: Great. Currently what do you do to increase your general content knowledge?

INTERVIEWEE: As I was saying with these workshops and then at times we meet as colleagues on how do you approach this topic. We sit down and normally just say how do you handle such a topic and then we have help each other on certain topics. Because there are new concepts in our syllabus now. So we always help each other there.

INTERVIEWER: And do you find it helpful to meet as a group of colleagues?

INTERVIEWEE: I'm telling you a lot. A lot, I'm telling you there are guys that will tell you there is a topic that we might be failing to handle and then you just comes and present, you learn a lot. With this one just do this and this and this and then you are done. The learners will just understand easily.

INTERVIEWER: What type of activity or support events would help you grow in your science knowledge?

INTERVIEWEE: What can I say here? I think here honestly I would need more experiments, more practicals, for that is what is lacking in my school and in my teaching here. If I can have all the kind of necessarily equipment, apparatus to say each and every topic is all it can be. Every learner is handling it, demonstrating and doing experiments I think that can help in my knowledge again and how to teach. Because as I was saying I saw the other one that says lecturer, it is not easy to always just be top, top, top, top, so I think that I need now a lot of apparatus. There are a lot of ones I don't know how to use, if I can be having those ones then it is going to help me grow a lot.

INTERVIEWER: Lovely. So when you say you don't know how to use it's because you haven't been taught how to use that apparatus.

INTERVIEWEE: Yes. I trained long back and they been using those traditional ones. Now there are easy ones like in titration, auto titration, all these burette ones, PH measure. There is a lot of PH meter that is user friendly. So if I can be updated on the technology in terms of experiments that I would love honestly.

INTERVIEWER: Lovely.

INTERVIEWEE: Because honest I've never used the modern ones.

INTERVIEWER: Perfect, thank you. In what ways would you define science teaching?

INTERVIEWEE: What ways define science teaching? That is a broad question right?

INTERVIEWER: Right, so if you compare it to English teaching what defines science teaching?

INTERVIEWEE: I can say science is to me is about exploring. It is not about content it is about exploring.

INTERVIEWER: Lovely.

INTERVIEWEE: Ja compared to just feeding the learners like here we teach them and they need to explore and understanding and the world around us infact. Not just to be taught. Like broad learning they are just taught and they don't know what is happening. To me it should be taught and then they know that it is about exploring naturally.

INTERVIEWER: Do you feel that it is important to relate to the concepts?

INTERVIEWEE: Yes a lot. So there should be ... basically this science should be applied science. It should be this as in relation to such, something in nature that is happening. So I think it should be related.

INTERVIEWER: Lovely. How do you think learners learn science best?

INTERVIEWEE: As I was saying they can only learn best by being involved, by doing practical's. I do, I remember. So I think they should be involved. In science nothing else they should be involved.

INTERVIEWER: What do you see as important to do or have to teach physical sciences effectively?

INTERVIEWEE: Right one learning aids. I always use of course charts and then two, enough apparatus, experiments, equipment. That one goes in hand with my presentations and then books with activities, I think it helps. Because with science learning every day they should have activities when they go home. So I think as I was saying learning aids, apparatus and then books with activities.

INTERVIEWER: When do your learners here in class learn science best?

INTERVIEWEE: In class learn science best, I don't know I can say when they learn it best or when they enjoy it best because honestly my learners when I tell them tomorrow they are going to experiment. That they enjoy and they become so excited. So that is when I can say now they see the need for science. They even say can we do it again tomorrow sir. Let's do the experiments every day and even others they want to do experiments. As long as when there is an experiment involved that is when the learning is effective to them.

INTERVIEWER: Do you believe in using hands on apparatus during the lesson? If so elaborate how often within a week you conduct a lesson with apparatus if you can when you can?

INTERVIEWEE: Basically here, yes the question is do you believe in hands on apparatus, which is fine I believe in that. But unfortunately, I don't do it often because of the I can say the situation of our school. It is not easy to do it often because we don't have a laboratory there. But I believe in this one. If all the laboratories there then twice or so a week. Or in the afternoons, especially Grade 12, do it in the afternoons.

INTERVIEWER: After school.

INTERVIEWEE: After school because that is when I do my formal experiments with the Grade 12's in the afternoon. During the day I cannot because it's one period. So from 2:00 o'clock up to 4:00 o'clock. Because I cannot do it within a period.

INTERVIEWER: So you do most of your practical activities in the afternoon.

INTERVIEWEE: In the afternoon yes.

INTERVIEWER: And like you say you do believe in hands on equipment or hands on apparatus and you say right now the thing that is stopping you the most is the lack of apparatus.

INTERVIEWEE: Yes correct and the facilities yes.

INTERVIEWER: Okay and the facilities.

INTERVIEWEE: Yes.

INTERVIEWER: Lovely. Okay so when you do carry out a practical if we look at the whole lesson what percentage of the lesson do you use textbooks, simulations and apparatus?

INTERVIEWEE: I think textbooks would be more like 75% and then apparatus it depends, I don't know, so 5%. Then simulations ... I'm on what number?

INTERVIEWER: That's 80%.

INTERVIEWEE: 80%. So I think the rest should be 10/10, 10% 10%.

INTERVIEWER: Okay. So basically from that you're saying you mainly rely on textbooks and then after that you rely more on?

INTERVIEWEE: I can say on simulations right because apparatus is only once in a while.

INTERVIEWER: What challenges do you have in the classroom teaching physical sciences?

INTERVIEWEE: I think this one mainly concentrate with grade 10s. Because I prefer having grade 10s, but I've taught natural science in grade 9 where I've laid the foundation on. But now the only challenge I have with grade 10s is they come from other schools without the background for physical science. So I have to start now from basic stuff from grade 9. So that is where I have challenge and then most of them will say I want to do physical science no matter what how much mark they got in natural science, they are here. So I have to know look at the basic stuff, the basic content for natural science. So even know I'm struggling as I was doing my lesson there is basics firsts and then I develop to the level that I am teaching. So it's not easy but Grades 11 and 12 because now they will be mindful of the past two years or so, I'm fine. Grade 10 is a problem.

INTERVIEWER: Okay so do you conduct all the experiments specified by the curriculum and do you rearrange the curriculum if need be?

INTERVIEWEE: Mostly the one that are prescribed we have to but if need be and time allow us we can do others that are informal ones. We are allowed to do that but as I'm saying the disadvantage is the lack of the equipment. So mainly when you order, and we normal order those that are prescribed so we can do them. Then I ... normally we it depends what we call, we can integrate the topics. So if I feel this topic can go hand-in-hand with this one we arrange it's allowed. So we do that yes.

INTERVIEWER: Lovely. Have you felt that you have always had the correct resources to teach sciences?

INTERVIEWEE: No, I can what you call this, I can improvise but no I've never felt like no I'm fine with the teachers resources. Especially in terms of experiments and apparatus. But textbook we are okay.

INTERVIEWER: Do you see waves as an important topic within the physical sciences curriculum?

INTERVIEWEE: Definitely, I totally agree, I totally agree. Because in grade 10 we develop it again to grade 11 to light and diffraction. And then in Grade 12 also from those concepts you're going to apply Doppler effect so I think it works well for me. And I've seen, sorry to say that, I've said now that's it's so exciting that we've alerted it to what you call this red shift and blue shift so it's really, really, what?

INTERVIEWER: Important.

INTERVIEWEE: Important yes.

INTERVIEWER: Lovely thank you. What resources do you usually use now to teach and illustrate the topic of waves?

INTERVIEWEE: I think basically as I was saying my ... our ripple tank is not functioning. So mostly I rely on my youtube, on simulations from my youtube, ya.

INTERVIEWER: What sub-topics or topics do you consider to be key in the topic of waves in grade 10?

INTERVIEWEE: Right, to me a sub-topic, electromagnetic waves, I'm slowing my voice now, electromagnetic waves and then sound I think those ones to me and they relate to my learners because every time that I teach it they've got real life examples at home and then even sound, pitch they understand it better, amplitude. So I think those two sound and electromagnetic waves to me relate well.

INTERVIEWER: Perfect. Would you tell me about your usual lesson plan, how you would carry out your lesson at the moment to teach wavelengths, frequency, period to your grade 10 lesson or learners.
INTERVIEWEE: My lesson on how I start, where do I start now? Because normally it is about the introduction and then this would be the first lesson.
INTERVIEWER: Yes all I want you to think about now is how do you teach waves to your grade 10s when it comes to wavelengths, frequency and period.
INTERVIEWEE: Yes and period. So I can say if because it's on the first day. Because now they don't have this prior and then ... but I think because there will be prior knowledge based on what you call pulses right? So know I will try and link it well with the pulses as a recap of the last period on which I did on pulses. Then wavelength of course I will link it now with pulses. I don't know whether I would be able to have done all the type of waves or longitudinal waves or the transverse. So I can just illustrate the transverse waves for them and try and show them what a wavelength. Then from there come up the cause of frequency and then relate frequency to period. So basically I think it would be based on them understood the topic of pulses and then I come and integrate pulses with wave and then I can come with the wavelength and then from there it is easy to come with frequency and period.
INTERVIEWER: Lovely and basically what you telling me now you keep facing the board. So you write it on the board, do you draw it on the board?
INTERVIEWEE: I draw it on the board yes. But as I was saying teaching aids, normally that one I put on a chart.
INTERVIEWER: A chart.
INTERVIEWEE: Yes so all the levels of a wavelength, frequency,amplitude and then I come up with the equation for frequency and period.
INTERVIEWER: Lovely and you mention the waves.
INTERVIEWEE: Yes.
INTERVIEWER: So basically your lesson to begin with is like you say on the board, using charts introducing these concepts, definitions.
INTERVIEWEE: Ja.
INTERVIEWER: Perfect. Now tell me exactly the same thing of what you would do but for superposition?
INTERVIEWEE: Okay. Superposition that one is always easier for me because when I talk about ... I always talk about constructing mostly because it is easier for

them to elaborate on constructive when I talk about how these waves meet then they give higher amplitude... so what is connected to water on the sea. Just see these ships at times they capsize because we're having a higher amplitude. Then destructive we do it with the raw data then we can see it cancels out. So it means that those ways were now in different phases. So I demonstrate and give life examples.

INTERVIEWER: Lovely so that like you say is the one thing you do demonstrate and you use ... what do you use to demonstrate?

INTERVIEWEE: I use a rope.

INTERVIEWER: A rope.

INTERVIEWEE: Yes.

INTERVIEWER: Lovely, perfect. Now we almost there. What do you expect students would have difficulties with in learning wavelengths? So what difficulties when you teaching waves now, what difficulties do they have when you teach wavelengths?

INTERVIEWEE: Wavelengths there is a problem with calculations of wavelengths. Especially when the wave it's a half wave, then you say calculate the wavelength, it's a challenge to them. Because they don't see it as a complete wave. So when it is not complete they cannot calculate number of waves. Then it is not easy for them to calculate wavelength.

INTERVIEWER: Perfect.

INTERVIEWEE: Frequency they are challenge, the frequency and period always confuse them. They want the equation of frequency and period so when it comes to calculation it is a problem. Expansion of frequency is fine but calculation it is a problem.

INTERVIEWER: Do you find that they mix the two?

INTERVIEWEE: They mix the two yes they do, frequency and period they mix the two always.

INTERVIEWER: Lovely and then the same thing what do you expect the students will have difficulties with when you talk about superposition?

INTERVIEWEE: Not normally, let me just think how they ... because I don't know superposition to me they always enjoy it.

INTERVIEWER: That's fine.

INTERVIEWEE: I haven't had any problems with it per say while in class. I don't know with this group maybe but when I talk about this one it's easy. Because I always demonstrate first and then they ... it's easy for them.

INTERVIEWER: They get it.

INTERVIEWEE: But those that have got ... what you call these things? Poor maths sometimes they fail even to ... if you give them the calculations, they calculate the amplitude maybe even pulses from different phases. At times they cannot calculate the magnitude after the two phases, what you call it?

INTERVIEWER: They combine.

INTERVIEWEE: Combine yes but basically it is not a problem.

INTERVIEWER: Lovely perfect. Now very similar but just in a different way. Learners often have misconceptions. So what misconceptions if anything is different do you believe are associated with wavelengths?

INTERVIEWEE: Mis-concepts associated with wavelengths.

INTERVIEWER: Even if you think about all your Sci-Bonotrainings that you do what problems do you find learners have when it comes to wavelengths?

INTERVIEWEE: Let me check

INTERVIEWER: If you believe it's the same it's the same.

INTERVIEWEE: Ja that's what I'm saying I think it's the same because to me the only challenge is on calculation on wavelength when they are given a scenario, maybe given a wave then they have to come ... maybe it is not easy for them to identify the number of waves. So it's ... I think that is why they've got misconception saying is this the complete wave or not. They don't even know where to start. Then of course they can see the crest and the trough but now to say the number of waves and then it's not easy for them. It is not easy.

INTERVIEWER: Perfect.

INTERVIEWEE: Frequency I think frequency when the equation is involved there it's a problem between frequency and period. It's always a problem and in the time it involves a number of waves it's a problem number when they have to count it's a problem.

INTERVIEWER: Okay.

INTERVIEWEE: It's a problem.

INTERVIEWER: So it's identification they're battling with.

INTERVIEWEE: Identification yes. When it's a straightforward like basic calculations they're just given it's fine. But when there is a diagram, number of waves, number of oscillations, it's a problem.

INTERVIEWER: Perfect.

INTERVIEWEE: Then superposition is only those minor ones if they've got proper grounding in maths. Just to see this one is above, this one is below then maybe destruction or its construction. Just to add simple has become for some that has got poor in maths.

INTERVIEWER: Lovely, perfect well that concludes our pre-interview with participate C. Thank you.

INTERVIEWEE: Thank you very much.

APPENDIX D: TRANSCRIBED SCRIPT FOR THE SEMI-STRUCTURED PRE-INTERVIEW, CRAIG

INTERVIEWER: Ok so today is the 11th of December I am with participant D carrying out the pre…um... pre-interview.

Ok, so, the age bracket that you are in 18 to 25; 26 to 35; 36 to 45, 45 to 60

INTERVIEWEE: 36 to 45

INTERVIEWER: Perfect, male…right what are your qualifications

INTERVIEWEE: Um, I have a masters in sustainable agriculture

INTERVIEWER: Perfect, masters in sustainable agriculture. Ok,

INTERVIEWER: Do you have a teaching degree? a PGCE?

INTERVIEWEE: No

INTERVIEWER: No no no, so you are going directly on your…

INTERVIEWEE: Yes,

INTERVIEWER: Perfect, on your masters?

INTERVIEWEE: yes

INTERVIEWER: Lovely, and your majors?

INTERVIEWEE: I…I majored in Natural resources

INTERVIEWER: Natural resources…lovely. At what institution?

INTERVIEWEE: The university of free state

INTERVIEWER: Oh wow, lovely, ok and the year you obtained it?

INTERVIEWEE: Ahhhh, I obtained it last year (2017)

INTERVIEWER: Oh wow, your masters

INTERVIEWEE: My masters, ya.

INTERVIEWER: And your degree?

INTERVIEWEE: A degree I have a BSc in agriculture

INTERVIEWER: Ok

INTERVIEWEE: In natural resources, I obtained it in 2002 at the university of Zimbabwe

INTERVIEWER: Ok wow, a Zimbabwean.

INTERVIEWEE: Yes

INTERVIEWER: Lovely. Ok so, right now are you, after your masters

INTERVIEWEE: Yes,

INTERVIEWER: Have…are you currently registered for any other science studies right now?
INTERVIEWEE: No, not yet
INTERVIEWER: No, not at all? Perfect…because you finished your masters last year.
INTERVIEWEE: Ya
INTERVIEWER: Well done, sho. This is what this is all about and it is exhausting, I can tell you.
INTERVIEWER: Ok so, have you…um… participated in any previous Physical Sciences training with regards to the curriculum? With regards to equipment?
INTERVIEWEE: Ya….like I've been to this CAPS training
INTERVIEWER: CAPS training
INTERVIEWEE: CAPS training Ya…when the curriculum was changing from the old one to CAPS
INTERVIEWER: And who carried that out?
INTERVIEWEE: It was, it was through the department
INTERVIEWER: The department, ok
INTERVIEWEE: Ya
INTERVIEWER: And where was it?
INTERVIEWEE: We, we were doing it um, by that time I was in D15, we were doing it, um, in Soshanguve. I've, forgotten the name of the school
INTERVIEWER: No that is ok
INTERVIEWEE: Ya
INTERVIEWER: Cool, perfect.
INTERVIEWEE: I think we spend about...ah...was 2 weeks
INTERVIEWER: Sho
INTERVIEWEE: Ya
INTERVIEWER: A whole two weeks?
INTERVIEWEE: Yes, because we were doing Grade 10 and we did grade 11 and then we did grade 12
INTERVIEWER: Ok
INTERVIEWEE: So we were doing like, it was content and also ah, on what was expected on the

INTERVIEWER: Ok

INTERVIEWEE: The new CAPS training

INTERVIEWER: So, you said it was mainly content

INTERVIEWEE: On content

INTERVIEWER: Did they, so basically was it you sat at a desk and they explained

INTERVIEWEE: Explained to you…Ya

INTERVIEWER: So it wasn't hands on?

INTERVIEWEE: It wasn't it was like, it was like…

INTERVIEWER: A lecture?

INTERVIEWEE: Like a lecture, sort of ya

INTERVIEWER: Ok so they didn't get you standing up and practising things and doing things and doing equipment?

INTERVIEWEE: Ya, doing, using equipment was there but limited

INTERVIEWER: Limited

INTERVIEWEE: Ya was limited, quite limited

INTERVIEWER: So, did you have any exposure to the equipment yourself or were you just watching?

INTERVIEWEE: Ya, I…I…we had exposure, that limited we had the equipment was there so some of the equipment was there

INTERVIEWER: And what type of equipment

INTERVIEWEE: Ah…what do you mean if you are saying what type of equipment

INTERVIEWER: So when you say there wasn't equipment there what type of equipment was, was it ah, dynamics track, was it test tubes what type of stuff was it?

INTERVIEWEE: It was like ah, most of the equipment which we used, like you say, test tubes, it was like…but for, for for mechanics it was it was there was nothing there

INTERVIEWER: Nothing there hey? Ok it was only limited

INTERVIEWEE: Limited

INTERVIEWER: Limited stuff

INTERVIEWEE: It was limited stuff.

INTERVIEWER: Perfect. Did you find it helpful, that training?

INTERVIEWEE: Ya it was, it was helpful because you get to experience what actually is happening and I think it will be easier for, to explain in class the visual

INTERVIEWER: Ok

INTERVIEWEE: Ya

INTERVIEWER: And how many years ago, do you remember, how many years ago what that training?

INTERVIEWEE: Aah, it was 20….10, 2011…

INTERVIEWER: Perfect, great

INTERVIEWEE: 2011, somewhere there.

INTERVIEWER: 2011

INTERVIEWEE: 2011

INTERVIEWER: Perfect. Now how many years have you been employed as a science teacher, as of the end of 2018

INTERVIEWEE: This is my 9th year

INTERVIEWER: 9th year

INTERVIEWEE: Ya

INTERVIEWER: Perfect and um how many years have you been teaching Physical science

INTERVIEWEE: Those nine years

INTERVIEWER: Also nine years

INTERVIEWEE: Ya

INTERVIEWER: Perfect. Ok so, what I am going to do now is I'm going to read out to you the different types of ways teachers teach and you can tell me which you think you are

INTERVIEWEE: Ok

INTERVIEWER: Ok, so the first style is telling and lecturing were the Teacher-centred involving lengthy period of teacher lectures. Students absorb and take notes.

INTERVIEWEE: Ya

INTERVIEWER: Ok…or demonstration…which is similar to lecturing style but includes some multimedia presentations, demonstrations and activities but are done by the teacher only.

INTERVIEWEE: Ok

INTERVIEWER: And that may be due to the fact that you only have one certain amount of equipment available. Hybrid or blended so it is tailor teaching styles to the learners needs. Trying to please every type of learner and their different learning styles within the classroom. A facilitator that initiates student self-learning and helps learners to develop critical thinking. Allows learners to ask questions and find own answers. Delegator guiding discovery. Inspiring students to reach a common goal and works with the learners.

INTERVIEWEE: Ah, I normally do the facilitation where I direct leaners, give learners the chance to do 1,2,3,4,5, things

INTERVIEWER: Awesome

INTERVIEWEE: on their own

INTERVIEWER: Perfect, ok

INTERVIEWEE: Because I don’t want them to distract when they are alone in the exam. They should, they should be used to, they get questions to answer on their own. I am just there

INTERVIEWER: 100%

INTERVIEWEE: To tell them where they have gone wrong and stuff.

INTERVIEWER: Lovely, perfect.

INTERVIEWEE: That’s how I operate

INTERVIEWER: Lovely

INTERVIEWEE: Ya

INTERVIEWER: Ok so what do you see as your strengths, teaching strengths?

INTERVIEWEE: It's like, my teaching, like I said, it's more of an interaction between me and the learners and a the way I take the learners , I make sure most of the time they are working on their own so that they get use to most of the stuff, I am just there to explain, give them the concepts and after that they will do most of the questions and also the things on their own.

INTERVIEWER: Perfect.

INTERVIEWEE: In that way they realise they won't get stuck when they are on their own, ya, they

INTERVIEWER: Lovely

INTERVIEWEE: Ya won't get stuck on their own.

INTERVIEWER: Great.

INTERVIEWER: What areas do you feel are relatively weak in your teaching, so where could You improve your teaching?
INTERVIEWEE: Ah, in my teaching I think I need to do more demonstrations, more demonstrations when it comes to some critical topics
INTERVIEWER: Are there any specific topics that you feel that way?
INTERVIEWEE: Um, Ya especially like I said especially mechanics
INTERVIEWER: Mechanics
INTERVIEWEE: Mechanics topics ya, lead to a lot of demonstrations like demonstrating Newton's laws, and more
INTERVIEWER: Ya
INTERVIEWEE: ya
INTERVIEWER: Because they battle with mechanics
INTERVIEWEE: They battle with mechanics, they battle
INTERVIEWER: I agree
INTERVIEWEE: Ya
INTERVIEWER: Ok so, currently now, what do you do to increase your general Content Knowledge as a teacher?
INTERVIEWEE: Like now what I normally do is, ah, each time before I start a topic, I will sit down go on the net, do as much research as I can, then I will also engage other colleagues from with our groups and check what's new which I don’t know about , how can I tackle 1, 2,3, 4 that way that’s how I…
INTERVIEWER: Brilliant
INTERVIEWEE: Do and, that's I do it.
INTERVIEWER: No that's good and do you find it helpful interacting with other teachers?
INTERVIEWEE: It's very very very helpful because we learn a lot of things everyday so that you know everything
INTERVIEWER: Of course
INTERVIEWEE: You learn a lot of things from others you know, you learn how to tackle some of the issues
INTERVIEWER: And what you may know another teacher might not know and vice verse

INTERVIEWEE: Vice versa ya. Like when it comes to physical science remember is physics and its chemistry

INTERVIEWER: You got to know both

INTERVIEWEE: You can't be up there on both.

INTERVIEWER: well done

INTERVIEWEE: Even within one section, with physics you can't know everything top notch.

INTERVIEWER: And accepting the fact that you need to learn

INTERVIEWEE: Ya that were most people would get it wrong, that this pride of if I ask

INTERVIEWER: Perfect

INTERVIEWEE: So at the end I always tell my learners, no don't be, remove that pride that you know, or what are they going to say. Just say it, ask questions. we also ask questions, we also look for answers, we also struggling answering some of the questions and you get info from colleagues

INTERVIEWER: Very much so

INTERVIEWEE: Ya, which is good

INTERVIEWER: Good. What type of activity or support events would help your growth in science knowledge?

INTERVIEWEE: I think, ah more of ah, going out to institutions like going to science, and going to sci- bono and you will get a lot of things, visualise a lot of things, you get some explanations which you will also be wondering what is actually happening

INTERVIEWER: Perfect

INTERVIEWEE: Ya

INTERVIEWER: Perfect. In what ways would you define science teaching. So how do you define teaching science?

INTERVIEWEE: Its more, its more, it is a mixture you have to be practical and also in other ways there is a lot of content which has to come with it. So it more of you have to visualise it for you to understand most of the things.

INTERVIEWER: Perfect

INTERVIEWEE: That's how I understand it because the more you visualise it the more you get the concepts.

INTERVIEWER: Brilliant

INTERVIEWEE: Ya
INTERVIEWER: And How do you think students learn science?
INTERVIEWEE: The students? Ya it's a bit, eish difficult, right, and um, with them like I said having them to visualise I think would be very very important to them.
INTERVIEWER: Ok, good. What do you see as important to do or have to teach Physical science effectively?
INTERVIEWEE: Like having materials, when I am saying materials its from your textbooks, a variety of textbooks from different guys then at the same time we have a equipment for you to do some experiments and for them to visualise then at the end having a lot of questions so you have a lot of workbooks so that they tackle as many questions as they can .
INTERVIEWER: Brilliant
INTERVIEWEE: Ya
INTERVIEWER: Perfect. When do your learners learn science best, in your classroom what have you seen, when do your learners learn science best?
INTERVIEWEE: Like ah, in my class I have realised ah if I attend my classes in the morning that's when they are, they will be so attentive before they get tired.
INTERVIEWER: Perfect
INTERVIEWEE: After break, it is a bit tricky so what I normally do is in the morning, that's when I, if I have them in the morning I do a lot of concepts if I have them in the afternoon its more of activities, group work and so that it's not .
INTERVIEWER: Ok
INTERVIEWEE: That thing that they have to grasp a lot of things but they have to work on their own, as groups and that way I realise that…
INTERVIEWER: It works best
INTERVIEWEE: Its working for me ya.

INTERVIEWER: Well done perfect. Do you believe in using hands on apparatus during the lesson? And if so, elaborate on how often within a week you conduct hands on activities if you do.
INTERVIEWEE: Ya it is very important to do hands on and ah if equipment is available, all of the sections which we have equipment ah we normally do the exp- demonstrations and some experiments and stuff, ya.

INTERVIEWER: And so you do believe its good to have hands on

INTERVIEWEE: Its very important, like I said it is more of visualising some of the concepts you have to visualise, you have to visualise. Like if you say ah doing exothermic reactions , if they see an exothermic reaction taking place it is easier for them to answer the questions that comes with the exam, rates of reactions, if you have those different conditions they have hands on so when you are explaining those theories they will understand them like the collision theory works like this because they visualise, if you have visualise something it is very very very easy for you to remember what you have visualised.

INTERVIEWER: Very much so

INTERVIEWEE: Ya

INTERVIEWER: Lovely. And do you find that the CAPS curriculum allows you time to do all the experiments?

INTERVIEWEE: The CAPS curriculum is loaded, I don't want to lie to you. Like ah, the things which are needed it is a lot of ah in covering the curriculum, eish it is very difficult for to have all the experiments and stuff, unless you if do a lot of extra classes

INTERVIEWER: Saying after school hours?

INTERVIEWEE: After school hours

INTERVIEWER: Is that what you are saying?

INTERVIEWEE: Ya, after school hours

INTERVIEWER: Ok, so you find that the apparatus and the practical work is difficult to do because of how demanding the CAPS curriculum is?

INTERVIEWEE: Ya, the CAPS curriculum, yes.

INTERVIEWER: OK

INTERVIEWEE: Because it is loaded

INTERVIEWER: Its loaded (laughing)….that's your word "it's loaded" (laugh)

INTERVIEWER: OK, right, um, so when you, during allocated practical time what percentage is spent on the following. So now there are three different scenarios; simulations that you have on the computer, hands on apparatus and textbook images. For example you have just said that the CAPS curriculum is loaded

INTERVIEWEE: Ya, is loaded ya

INTERVIEWER: So sometimes you may not have the time to do all of this, but in a practical lesson,
How much of that time do you spend trying to use simulation, apparatus and textbooks? If you look at percentage of 100 and you break it up.
INTERVIEWEE: Ya most of the time we end up, we are for practical's we end up using use simulations, just going on youtube, then we get
INTERVIEWER: Youtube you said hey?
INTERVIEWEE: Yes, then you get those, then you put them on the screen
INTERVIEWER: Quick and easy
INTERVIEWEE: Quick and easy, then ya, so most of our time is more of simulations, then a textbook. Like hands on,eish, is taking smaller percentage.
INTERVIEWER: A smaller percentage out of those three. So you would say you use simulations from youtube the most
INTERVIEWEE: Ya followed by
INTERVIEWER: Textbook images
INTERVIEWEE: Ya, the it comes to hands on
INTERVIEWER: Hands on after.
INTERVIEWEE: Ya
INTERVIEWER: Perfect. Thank you. Right so what challenges do you have in the classroom teaching physical science at the moment, forgetting that I am here, at the moment what are your challenges?
INTERVIEWEE: Like I, the challenges, like I've said, because the curriculum is ah, is a loaded, like I said ya, time to do practical work is so so so limited. It is very very limited. And that’s a cause for concern.
INTERVIEWER: Ok
INTERVIEWEE: Its really a cause of concern. Ya, but where we are able to do it, we are ya, doing it but not the way we want.
INTERVIEWER: Ok
INTERVIEWEE: Ya
INTERVIEWER: And um…do you at the moment have the equipment for all your CAPS topics?
INTERVIEWEE: No we don’t have ah all of it, ya.

INTERVIEWER: Ok you don't have all of it. What type of things do you currently have?

INTERVIEWEE: Like ah ya, there this we have ah some of the stuff, like ah, for for ah, test tubes and burettes we have ah scales we have a lot of chemicals we have for ah for what you call those rails for

INTERVIEWER: Dynamics tracks

INTERVIEWEE: Dynamic tracks ya,

INTERVIEWER: The rails, ok

INTERVIEWEE: We have those ya.

INTERVIEWER: You have those. Perfect. Right and do you conduct all the experiments specified by the curriculum? We have spoken about this but…

INTERVIEWEE: Yeah not all of them. That's why I said most of the time we end up being the simulations, ya.

INTERVIEWER: Perfect Have you felt that you have always had the correct resources to teach science?

INTERVIEWEE: Ah, (laughing)

INTERVIEWER: So what is that answer? Yes or No (laugh)

INTERVIEWEE: No (laughing), that's a no

INTERVIEWER: That's a no (laughing)

INTERVIEWEE: That's a no.

INTERVIEWER: OK, perfect.

INTERVIEWER: Um, so now we are moving onto when we focus mainly on the topic of waves, for Grade 10's

INTERVIEWEE: Ok

INTERVIEWER: Ok

INTERVIEWER: So… do you see waves as an important topic within the Physical Science curriculum

INTERVIEWEE: Yes, waves are very very important, in that curriculum because if you check, ah most of the things revolve around the waves, ya.

INTERVIEWER: Ok

INTERVIEWEE: most of the things revolve around the waves

INTERVIEWER: Perfect

INTERVIEWEE: So it's a very important topic, it's a very important topic.

INTERVIEWER: Ok and do you teach it in Grade 10, 11 and 12?

INTERVIEWEE: Ah like Grade 10 that's where we having like thee waves on their own then we apply the concepts in Grade 11 and 12.

INTERVIEWER: Perfect, lovely. What resources do you usually use right now to teach and illustrate waves?

INTERVIEWEE: I normally use simulation.

INTERVIEWER: Simulations

INTERVIEWEE: Ya

INTERVIEWER: And only simulations?

INTERVIEWEE: Simulations and textbooks, that's what I use.

INTERVIEWER: Ok so right now tell me again what are the two things that you use?

INTERVIEWEE: Like I said, I said Simulations and textbooks.

INTERVIEWER: Perfect. What sub-topics, so we got waves, ok now waves is broken up into sub-topics or concepts do you consider to be key in the topic of waves in Grade 10? List them for me.

INTERVIEWEE: Right um.. superposition I think is very very important after knowing the waves on its own, what is a transverse wave, what is a longitudinal wave, then ah superposition is very very important. Then also after that the wave speed or to calculate frequency, period and waves speed.

INTERVIEWER: Ok lovely. Perfect thank you. That's great. Would you tell me about your usual lesson plan and tell me how you would carry out the lesson to teach wavelength, frequency and period to your Grade 10 learners? How would you go about it if you visualise yourself in the classroom?

INTERVIEWEE: First of all I, I get them to know what is a transverse wave, what is a longitudinal wave. That's the first port of call. Then after that I draw for them so that they visualise how a wave usually the transverse wave looks like, showing them the trough the crest then showing them all the points where they can pick the wavelength , then from there the amplitude, then from there we do all the definitions, what is wavelength, what is frequency what is the period. Then from there, after doing all those definitions we go for calculations and stuff.

INTERVIEWER: Perfect, ok. And during that lesson plan you have said that you mainly use simulation, at that point do you introduce a simulation or do you only do simulations later?

INTERVIEWEE: Like I will do simulations after we have done the definitions then we do simulations so that they will see so how those waves look like and how they behave.

INTERVIEWER: Perfect. Would you tell me about your usual lesson plan and tell me how you would carry out the lesson to teach superposition to your Grade 10's

INTERVIEWEE: Like ah superposition, what I normally do is first of all I explain to them how waves moves right, and in the direction between the waves, and then the positive and the negative, then from there we look at what happens if they are on one side and that's where I will superposition takes place.

INTERVIEWER: Perfect.

INTERVIEWEE: How they will cancel each other or how they add up each other.

INTERVIEWER: Perfect, brilliant and again when would you do your simulation or textbook or activity? What would you do at that point?

INTERVIEWEE: I will do the simulation after explaining to them what is actually happening. Normally I make them to draw their own diagrams , I will show them how to draw then I will give them examples then I say draw and explain to me draw and explain to me and then after that we will do the simulation so that they will see how

INTERVIEWER: It changes,

INTERVIEWEE: Yeah, how it changes and takes place.

INTERVIEWER: Brilliant. Ok and what do you expect students would have difficulties, Ok so now you are thinking about learners, what difficulties do they have when they learn about wavelength?

INTERVIEWEE: Normally when they learn on wavelength, what I realise on wavelength normally if they are, for them to identify where to pick the wavelength.

INTERVIEWER: Perfect

INTERVIEWEE: Ya, because remember there are a number of positions where you can pick the wavelength. That's thee..

INTERVIEWER: The main thing

INTERVIEWEE: Ya

INTERVIEWER: Perfect, ok and the same thing but now for frequency?

INTERVIEWEE: Frequency normally ah its when you, normally when you are given period, for them, they normally forget how to take it to frequency or when they are given this number of waves at a certain period knowing the definition of frequency that is per second.

INTERVIEWER: Brilliant,

INTERVIEWEE: Yes something like that

INTERVIEWER: Brilliant, so basically you have also covered about Period

INTERVIEWEE: Yes

INTERVIEWER: So you say, um, say again what you find they have difficulty with period?

INTERVIEWEE: If you gave them frequency taking it back to, they normally struggle or normally forget that formula that period is one over frequency, they normally forget it. That's was they…

INTERVIEWER: Perfect and the difficulties they have with superposition?

INTERVIEWEE: Superposition, the difficulties that which they have is the direction of the waves. Which is it are they all in phase or out of phase or are they ya, is it positive amplitude and negative amplitude are they cancelling or adding each other, they normally forget.

INTERVIEWER: Ok, perfect, this is very similar but I am just going to ask it again as the last question. What kinds of students' misconceptions are associated with a lesson teaching about wavelength?

INTERVIEWEE: Like when we are talking about the wavelength normally, they think it's the number of waves that were (laugh), you have to explain to them no its not the number of waves its were the wave repeats itself its not the number of waves. That's were their problem is, ya.

INTERVIEWER: Perfect and the misconceptions they have about frequency?

INTERVIEWEE: Frequency, normally they confuse it with ah, with amplitude.

INTERVIEWER: Ok

INTERVIEWEE: Ya, with the amplitude, I don't know how, we have cases where I am always surprised how they ya

INTERVIEWER: Frequency and amplitude are confused.

INTERVIEWEE: Where they are confusing it, ya.

INTERVIEWER: Ok and with period?

INTERVIEWEE: Ah with period its where they having the complete wave, right , it confuses them, like knowing especially if its not on the zero line when the wave is not on the zero line. Like Picking it from the crest or the

INTERVIEWER: Trough

INTERVIEWEE: The trough, ya.

INTERVIEWER: And superposition? What are the misconceptions that they have about superposition?

INTERVIEWEE: Ah super positioning where they normally have a problem is when they are coming one below and the other one at the top, that cancelling, eish,

INTERVIEWER: Eish, (laugh)

INTERVIEWEE: Yes it's a real problem

INTERVIEWER: Ok

INTERVIEWEE: yes

INTERVIEWER: perfect.

INTERVIEWEE: Yes, yes.

INTERVIEWER: Lovely, ok, well thank you that is now the end of our pre-interview

INTERVIEWEE: Ok

INTERVIEWER: So let me just stop this now.

APPENDIX E: DIARY REFLECTION OF THE INTERVENTION FOR JESSICA

The following represents the diary reflection notes made directly after the intervention. The time placed in brackets after certain reflection notes indicates the section of the intervention recording that supports the reflection note. The notes and recorded sections were further used to prepare for the Trainer audio stimulated recall interview.

1. How long did the training take?
   1h 1min 58sec of recorded content.

2. Was the teacher receptive?
   The participating teacher was very receptive. The participant was both receptive and interactive (00:55:00). She was consistently listening and did engage with myself and the trainer even without being prompted to do so. The participant initiated a discussion about other ways in which she uses the ripple tank when they do decide to use their older wooden version ie: placing the light under the ripple tank base to project the image onto the roof (00:06:30 and 00:32:00). The participant also engaged with the trainer after the trainer addressed the misconception about how learners assume that the light lines seen are the troughs and the darker lines seen are the crests. The participant indicated that she does in fact extend her learners knowledge by teaching the reason as to why the crests are in fact the darker lines and the troughs are the darker lines (00:16:50).

3. Did the teacher ask questions?
   The participant did not really engage in the form of asking questions. The only question was with regards to the balls used to produce the circular waves which became evident when we illustrated it using the ripple tank. The participant engaged in discussion while stating a few things ie: how she used the tank previously rather than asking questions.

4. Did the teacher seem to have a baseline understanding on the topic of waves?
   Yes. Although young and new to teaching Physical Sciences, the teacher did have an understanding of the topic and was quite knowledgeable about the topic. The participant

made sure to indicate that the school does not focus too much on the concept of superposition (00:14:15).

5. Did the teacher seem to have a baseline understanding on the use of the ripple tank apparatus (ie: was she new to the ripple tank or not)?

   To begin with the participant had quite a negative perception of the ripple tank (00:00:31). The participant acknowledged that she does not use the ripple tank to its full extent and relies more on the use of the light kit and the slinky spring to demonstrate waves (00:29:10). The participant asked whether the ripple tank would leak while she was pouring the water into the tank base. This indicated to me that she did not have confidence in the apparatus (00:09:00). The participant also noted that the current ripple tank the school owns, is an older wooden version that leaks and has a motor which is slightly faulty (00:09:00 and 00:12:00 and reflection (00:12:58).

6. Was there anything that stood out during the training?

   Although the participant came across as quite knowledgeable about the topic and about the ripple tank, I felt that the participant still learnt something through the intervention. Evidence of this was seen through her excitement:

   a) When we introduced her to the use of the stroboscope (00:07:07).
   b) Through the use of the speed controller to change the frequency and thus wavelength of the waves, especially when viewed through the stroboscope (00:18:41 – 00:19:20).
   c) When we related the concept of diffraction to a real-life photograph taken off google map which showed diffraction around an island based in South Africa along the Western Cape (00:33:40).
   d) When viewing the concept of diffraction through the stroboscope when she stated, "that’s cool" and "this is so trippy" (00:37:35 – 00:38:08). This was further evident when she discussed how her learners will state what they see using the ripple tank as "trippy".
   e) When shown the use of the curved metal plate to illustrate reflection (00:48:00).

   The participant indicated her approval of the ripple tank when we indicated and discussed how the training was conducted in a fully lit room using only the ripple tanks LED light however, the waves were still clearly projected and seen (00:25:09) and (00:51:20). Therefore, the participant became fully confident in the apparatus after seeing that the waves were easily observed in the fully lit classroom and that the tank did not leak (00:09:00). The participant also acknowledged that the tank design and its better designed properties reduced the amount of reflection that took place when the waves were generated by hand and by the motor.

APPENDIX F: DIARY REFLECTION OF THE INTERVENTION FOR TSHUMA

The following represents the diary reflection notes made directly after the intervention. The time placed in brackets after certain reflection notes indicates the section of the intervention recording that supports the reflection note. The notes and recorded sections were further used to prepare for the Trainer audio stimulated recall interview.

1. How long did the training take?

   56min 09sec of recorded content

2. Was the teacher receptive?

   Yes, the participant was receptive and interactive seen by the way he agreed and nodded with actions and words that the trainer would use and the concepts the trainer would explain. The participant would often either repeat after the trainer or would whisper an answer while the trainer was explaining, which often involved the correct answer/explanation (00:17:00 – 00:18:00).

3. Did the teacher ask questions?

   During the training the Participant mainly listened and absorbed but at the end of the training he did ask whether the ripple tank should be used for Grade 10 and during the lesson observations that I would attend because he was aware that the study was relevant to Grade 10. Both the trainer and I reiterated that it was a decision he could take, leaving it totally up to him. He mentioned that he felt more confident explaining the Grade 11 topics with the ripple tank than the Grade 10 foundational concepts.

4. Did the teacher seem to have a baseline understanding on the topic of waves?

   Yes. I could see that the Participant was 'hungry' for knowledge and is a keen learner. The participant would acknowledge where in the curriculum the topic and its relevant concepts were covered ie: Diffraction. The participant knew that the study was to focus on the Grade 10 level. During the training, we covered the concept of Diffraction. He did seem concerned that we were covering the concept and thus asked if he would have to cover it in Grade 10 instead of Grade 11. We assured him that his thinking was correct and it is part of the Grade 11 curriculum and should continue to teach it in Grade 11 (00:30:35).

5. Did the teacher seem to have a baseline understanding on the use of the ripple tank apparatus (ie: was he new to the ripple tank or not)?

   The participant knew what the apparatus was and the section it should be used for. However, he admitted that the last time he saw the apparatus and the apparatus in use was during his teaching training in 1999 (00:55:55). He mentioned that an old ripple tank apparatus was somewhere in the next-door classroom but was unworkable. He found joy in using the stroboscope and loved the visualisation of the waves using the ripple tank as he would often use the phrase "nice one" (00:26:40). He also seemed to be intrigued when he observed the effect of reflection using the concave metal barrier (00:27:50). The participant also showed delight when the trainer illustrated the concept of diffraction when the two longer metal barriers were used to produce a slit/gap (00:31:30)

6. Was there anything that stood out during the training?

   At the end of the training the Participant acknowledged that he needed to practise again using the apparatus even after using the apparatus during the training. After clarifying which Grades he should use the apparatus for he indicated that he was excited to use the apparatus for Grade 10 and 11 (00:54:50) and that he was happy and had learnt a lot (00:55:50).

APPENDIX G: DIARY REFLECTION OF THE INTERVENTION FOR CRAIG

The following represents the diary reflection notes made directly after the intervention. The time placed in brackets after certain reflection notes indicates the section of the intervention recording that supports the reflection note. The notes and recorded sections were further used to prepare for the Trainer audio stimulated recall interview.

1. How long did the training take?
   1h 3min of recorded content

2. Was the teacher receptive?
   I witnessed that the participant was more receptive than interactive. He was consistently listening but engaged very little with the trainer and myself unless prompted to do so or unless questions were asked by the trainer. The participant would agree with the things said by the trainer and would often repeat sentences which were said by the trainer (00:03:30; 00:04:55; 00:22:50). This indicated to me that the participant was focused.

3. Did the teacher ask questions?
   The participant generally did not ask questions during the training. The one question he did ask was whether the tank would leak (00:07:58) while he was pouring the water into the tank.

4. Did the teacher seem to have a baseline understanding on the topic of waves?
   Yes, the participant did seem to have a knowledge of waves but he was not very expressive about it. Due to this I would remain in saying that he was more receptive in gaining knowledge that interactive by expressing his knowledge. He listened with intention to gain knowledge expressed by the way that he continuously said the word "OK" (00:02:30; 00:04:55; 00:06:40-00:06:56; 00:23:50; 00:24:15).

5. Did the teacher seem to have a baseline understanding on the use of the ripple tank apparatus (ie: was he new to the ripple tank or not)?

The participant knew what the apparatus was and the section it should be used for. However, he was not very knowledgeable on this specific ripple tank apparatus– this is what I observed while we were setting up the apparatus. He acknowledged the use of the apparatus and the use of the individual items that made up the apparatus but did not suggest other ways to use the individual items. This indicated to me that he was attentively learning about the apparatus and what it could do (00:18:25).

6. Was there anything that stood out to you during the training?

   At the end of the training the participant stated, "visuals are good" (00:58:38), "they see what is actually happening" (00:58:45-00:58:53). The participant indicated that he wanted to explore the apparatus more and to play around with it (00:59:06-00:59:17). The participant expressed that he knows learners understand better when seeing and thus indicated that the apparatus is visual which will help (00:59:19 -00:59:29).

   During the training, the teacher indicated that the apparatus is important for Grade 11 because that is where the concepts of diffraction, refraction are covered and are applicable for using the apparatus (00:59:50 – 01:00:09). He mentioned that at the Grade 10 and 11 level the learners need to understand the foundational concepts because if not 'it would be something else' (01:00:19 – 1:00:45). He thanked us for the "technology" and also mentioned that "the kids will be excited to do this stuff" (01:02:56 – 01:02:14).

APPENDIX H: DIARY REFLECTION OF THE OBSERVATIONS AND THE SEMI-STRUCTURED VSR QUESTIONS FOR JESSICA

Lesson 1

She introduced waves with a slinky. She chose to start the introduction of simple terms and the definitions of a wave, energy and a medium. This was followed by real life examples of waves and then demonstrating waves with a slinky. She further discussed the definitions and drew a diagram of a wave on the board. Throughout the lesson she made the learners observe and come up with their own terms for what they were observing even if slightly incorrect. The learners came up with some terms while others were only through her prompting ie: amplitude. The teacher made learners aware that they tend to confuse the concept of period and frequency and thus need to ensure the understanding of both and their differences. Other observations:

- The participant engages well with the learners asking them by name to give the answers.
- Her teaching style allows learners to learn through exploration.
- She was aware of learner prior knowledge and made use of real-life examples to allow concept development.
- She identified a well-known misconception.
- She made good use of different resources: workbook, slinky and a diagram.

VSR questions

(Using the first video of Lesson 1)

Note to self: Skim through the lesson just for the teacher to briefly recall the events as a sequence.

1. What teaching methods and activities did you use during the lesson?
   Evidence: 05:30 showing use of slinky, **13:20** went back to the board, **16:26** use of the diagram,
2. Explain the reasoning in the order of events used in this lesson.
3. How did you determine learner prior knowledge?
   Evidence: Seen when using the slinky spring.
4. During **21:00-22:53** and at **24:21** learners had a question about *a pulse* and a *wave cycle* and about *a pulse* and *a wavelength*. How did you address this?
5. Looking back at your lesson – which teaching style best describes Lesson 1.
   (Do have the teaching styles available so that the teachers can familiarise themselves again.)
6. Indicate to me your thoughts on how you feel about the lesson you taught and the representations you used.
7. Was it evident that the learners were engaged in this lesson?

Lesson 2

The lesson started with the participant explaining that had covered the calculations and definitions of waves. She used the lesson to move on to the properties of the waves and how they behave. The participant started by asking the learners about *interference, reflection, refraction, diffraction* and the real-life examples of their application ie: glass of water with a straw; light through the door coming in from the passage. She got the learners involved by getting them to illustrate the Mexican wave to make them understand *wave fronts* and the 3D effect of what they have seen in 2D, as an image on the board. She also discussed *in-phase*. She made use of the ripple tank using it exactly how she was trained to cover the concepts of reflection, refraction, diffraction and interference. She however, did not use it to show the phenomenon of *wavelength* and *frequency* as shown in the training. She jumped straight into illustrating the more complicated phenomena. I noticed that she did not make use of the stroboscope.

At the end of the lesson there was some time before the bell rang. The teacher allowed learners to 'play' with the apparatus by combining which ever pieces of the apparatus they wished to use. However, the learners were instructed that they had to predict what they thought would happen and were not allowed just to randomly place barriers or prisms into the tank for random fun sake. They had to have an answer indicating what it is they predict would happen using each scenario.

The ripple tank was already set up so I did not observe her setting it up. Although the teacher herself did not set it up it would have involved a certain amount of organisation to alert the technician to have it set up in time for the lesson and therefore, I can assume that she was organised in this regard.

VSR questions

Note to self: It was from **19:40-21:00** that she started to introduce the ripple tank as a representation.
Note to self: Skim through the lesson just for the teacher to briefly recall the events as a sequence.

Using the first video of Lesson 2:

1. I noticed that you jumped straight in to demonstrating interference, reflection, refraction, diffraction, repeating it with circular waves. Explain the reasoning in the order of events used here.
2. Please mention again why in Grade 10 you cover all four phenomenona.
3. The action seen in the clip starting at **08:03** looks similar to what was shown during the training, is it something you took from the training or have you always demonstrated reflection using a curved surface?

4. You mentioned previously that you like to use the light kit. Of what I observed, only the ripple tank was used. Did you choose the ripple tank over the light kit, or was it due to time constraints or the appropriateness of the topic at hand?
5. At **22:45** when you showed the learners the phenomenon of reflection the word "Trippy" was used by the learners. What does this indicate?

Using the second video of Lesson 2

Note to self: Skim through the lesson just for the teacher to briefly recall the events as a sequence.

6. During the clip, staring at **04:15**, to get the learners thinking you described a slit and falling rice. You ask the learners what they think they would observe. This was very similar to the example used during the training with the use of sand. Have you always used this example or did you use what you learnt from the training?
7. Was your lesson effective? How do you know?
8. What was the level of learner's participation during the lesson?
9. Do you think the learners learnt what you intended them to learn in the lesson? How do you know?
10. How do you feel about the lesson you taught and the representations used?
11. Did you feel confident in the lesson using the ripple tank?
12. Would you have felt as comfortable using the ripple tank had you not had training on the apparatus?

Lesson 3

The teacher recapped reflection, refraction, diffraction and interference by asking the learners what they thought about each term. After which the lesson focused on superposition. The teacher reiterated that it was not a big section that had to be known for matric and therefore they would not be going into it in much detail. However, I felt this was one of the better lessons she taught, despite it not being crucial for the matric final paper. The teacher used an analogy - 'good' and 'bad' interference to describe an increase in size and decrease in size of waves. A learner took it quite literal and the teacher had to address his confusion which she did. The teacher then went to the back of the classroom with the learners to demonstrate interference using a slinky spring. Knowing what it was that should have been seen, I could observe the effect using the slinky spring but only very briefly. The learners were battling to observe the effect because it was not obvious. As a result, they were not describing the effect very well. The teacher was patient and adjusted her questions accordingly sometimes having to state what should have been observed in order to get the learners onto the 'same page'. The teacher was aware that it was not the most effective way to illustrate interference but knew that using the slinky as a representation would stimulate learner involvement. The teacher then drew a diagram on the board of the phenomenon. After which a simulation was then projected and also explained. After which the ripple tank was used. To start she illustrated interference through the reflection of waves off a barrier before using the circular waves to illustrate superposition. Other observations:

- It was a well thought out lesson.
- The teacher illustrated her patience and adaptive nature.
- She had a good use of representations.
- She addressed the learners' questions, misconceptions and concerns well.
- She used the ripple tank as shown in the training.

VSR questions

Note to self: Skim through the lesson just for the teacher to briefly recall the events as a sequence.

Using the first video of Lesson 3:

13. What teaching methods and activities did you use during the lesson?
14. At **5:15** through to **5:53** a learner asks a question regarding the analogy you used – how do you address his misconception on the analogy?
15. During the clips of **8:45 -11:20** and **14:00-15:05** the slinky spring is being used to demonstrate constructive interference and destructive interference. How do you feel this representation went?
16. In the same clip a learner addressed his same misconception as before. Do you think his misconception was addressed?

Using the second video of Lesson 3:

17. At **3:50-4:10** you have a discussion with a learner about the crests and troughs and how they are presented as lighter and darker lines. You hint that "according to science it may be the other way" to what he thinks. You also mention that you would prove to him later. Why do you say this?
18. During **5:43-6:12** a learner says that what she is seeing reminds her of something (hypnotism). Although irrelevant what do you believe this comment indicates?
19. Out of the three representations which did you feel addressed or illustrated the phenomenon the best?

Note to self: Other prompts to ask
1. Which lesson/sections of a lesson were the learners most engaged? 2. What is your reasoning for this observation? 3. Which lesson best approached and dealt with the learner misconceptions? 4. What is your reasoning for saying this? 5. How will you be able to know whether your students understand the concepts you taught? 6. Out of all the concepts looking back, which concept did you find the easiest to teach and why? 7. Did you make any changes in the lessons that I observed compared to previous years and other classes or lesson plans? Why? 8. Do you believe what you planned out to achieve was achieved when coming to carry out the lesson or did you deviate from your planned lesson? 9. What changes would you make the next time you teach the same concept?

APPENDIX I: DIARY REFLECTION OF THE OBSERVATIONS AND THE SEMI-STRUCTURED VSR QUESTIONS FOR TSHUMA

Lesson 1
It is evident that the teacher has already started teaching the topic of waves. He spent this lesson recapping some definitions to include *amplitude* and *wavelength* and the different formulae used to calculate *frequency, period* and the *speed of a wave*. Throughout the lesson the teacher asks questions and waits for learners to answer. He often asked learners by name to answer. The teacher handed out a past paper with a set of questions on it and worked through it with the learners. The teacher would often ask the question "why" after a learner had answered a specific question in doing so initiating further thinking. While going through the question paper he would ask the question and then would wait for an answer, therefore not just stating the answer or answering his own questions. The participant draws a diagram on the board of a transvers wave during an explanation. He often is seen giving out 'hints' on how to approach or answer a question ie: "the question asks you to *calculate* not *state*" which shows he himself understands and is further trying to help his learners understand. Again, he checks in with the learners if they understand. Another set of questions are placed up onto the board via the projector and learners are given 15 minutes to complete them. The question was referring to the ripple tank which he mentions is a piece of apparatus that they will be shown at a later stage. The second question mentions 13 consecutive wave crests and hints to the learners that 13 is not the number of waves and hints to them to be careful when answering this question. He reiterates what the term period means. Further in the lesson after discussing amplitude he states how he can see that the learners are frustrated with the concept of amplitude (because they are given the distance from crest to trough and some don’t understand why its incorrect to state that given value rather than dividing it by two). He collects the books at the end of the lesson to mark the exercise. Other observations: - The participant interacts and engages with the learners very well. - His lessons are prepared and organised. He also identifies a number of misconceptions during his teaching and makes learners aware of them. - He makes effort in making the learners answer. - He makes effort in making the learners understand WHY an answer is relevant. - He is observed to repeat important aspects a lot and shows evidence of identifying problem areas. - I do find the participant very rushed, wanting to maximise the time given to him. In doing so he often tells learners that he is going to give them 5 minutes to complete work but in fact gives them '2 minutes' while discussing things in between. He was aware of this as discussed in the pre-

interview.

- Unfortunately, although indicated by the participant to come from todays lesson, he had already covered the foundational concepts of wavelength, frequency and period and therefore I have not observed him teaching them.

VSR questions

(Using the first video of Lesson 1)

Note to self: Skim through the lesson just for the teacher to briefly recall the events as a sequence.

1. Describe to me what you taught to the learners on the topic of waves before I started observing.
2. Explain to me the order in which you taught it.
3. During **2:40-2:57 and 6:00** what do you observe yourself doing here and why?
   Evidence: The teacher identifies the misconception of wavelength. He also warns learners of how they will confuse "the situation".
4. Describe to me what you did in this lesson before you gave out and began discussing the past paper questions?
5. During the clips of **06:30-06:50** and **11:30-11:51** you ask the learners to explain "Why". What was your reasoning for doing this?
6. Observing your actions at **08:10,** please explain to me your thought pattern – why did you say that you and the class would start fighting**?**
   Evidence: He said that he and the learners were going to start fighting about the next question regarding how many complete waves seen in the diagram. He and the class had a good discussion. He also repeated himself a number of times to ensure they understood.
7. During **17:00-20:00** a learner is confused and asks a question as to where one of the values the teacher used originates from. The participant doesn't ignore it and shows her. This clip also illustrates that he allows learners to discuss questions and answers before giving the answer.
8. Between **19:00-19:42** what do you observe yourself doing here and why?
   Evidence: A learner asks a question about using a second method to calculate. He accepts and even goes into it by doing the example on the board to show that the same answer is given.
9. From **19:50** through to **20:10**, what do you observe yourself doing here and why?
   Evidence: He reiterates to the learners that he is aware that calculations cause problems.
10. Do you feel that the learners were engaged in this lesson?

11. Give me your thoughts on what style the lesson was based upon. (Do ensure to have the teaching styles available to the teacher).

Lesson 2

Yesterday the teacher apparently introduced longitudinal waves and the aspects of the wave compared to the transverse wave. Today's lesson was well thought out and planned. It started with the teacher asking the learners to distinguish between the two waves in relation to their propagation and properties ie: Right angles vs parallel, crests and troughs vs compressions and rarefactions. He would wait until a learner would answer and insisted in hands being put up. Although the lesson was well thought out, he had learners take majority of the lesson to discuss the questions given the previous day on longitudinal waves. I therefore, did not observe him teaching very much during this lesson.

Note to self: The learners in my opinion did extremely well. They presented well. They wrote answers up on the board. They even asked other learners to answer, by name. They went through each homework question and gave the answers. Not only did they give answers but they explained why it was the answer ie: "why was it the crest?", "Because it is the highest point on the graph". The learners would not move on to the next aspect until they got acknowledgement from the class that the class understood. The teacher allowed the learners to take the lesson until he felt the need to add in further information. The learners during the calculations seem to handle them well and at one point even understood that there was more than one way of calculating the same value for frequency. The learners taking the lesson at one point (25:50) saw a learner that looked disinterested. By name she asked this learner to reiterate how they got the previously discussed answer- he didn't know, after which it was discussed again. Towards the end of the lesson the teacher then asked the learners to guess a real-life example of longitudinal wave. They came up with sounds waves after seeing the next page in the textbook. Learners were then left to complete questions from the textbook. He then asked which two learners would like to be in charge of introducing sound waves tomorrow but no one was up for the challenge. Although no apparatus was used the teacher still got the learners fully involved

VSR questions

(Using the first video of Lesson 2)

Note to self: Skim through the lesson just for the teacher to briefly recall the events as a sequence.

12. At **1.30** you ask the learners "what do you see". Is this something you learnt from the training?

13. At the point of **2:00** within the lesson you ask two learners to come up to the front of the classroom who have prepared for the lesson. What was your reason for doing this?
14. The learners were well prepared which is evident by the fact that they had a poster prepared and made and they were well equipped to answer the questions from the textbook. What was your instruction you gave them during yesterday's lesson so that they were prepared for today?
15. I see that the learners not only give the answer but they also explain "why" it is the answer. What does this indicate to you?
    Evidence: 04:40; 0**5:40;**
16. At **9:00** through to **10:09** the learners explain the propagation of the waves. You allow them to continue and at **09:33** and again up to **10:09** you are heard to add to the conversation**.** Why do you allow the learners in the front of the class to continue, only adding to the conversation at a later point?
17. At **11:00** you ask the learner who answers a question, not to use the textbook but rather to explain in their own words and then to also explain **why**. What is your reasoning for this?
18. At **12:00**, a learner says that speed is velocity. How did you address this situation?
19. During **15:15** and again **23:10-23:46**, what do you observe happening here?
    Evidence: The misconception of determining the number of waves is evident as they did not understand how the learners taking the lesson got to 2.5 waves and 3 waves respectively.
20. What representations were used in lesson 1 and 2?
21. Looking at your lesson 1 and lesson 2 – which teaching style best describes lesson 1 and 2?
22. Give me your thoughts on what you feel was the level of learner's participation during lesson 1 and 2?

Lesson 3

The lesson recapped the idea of longitudinal waves and its comparison to transverse waves. The teacher then related longitudinal waves to sound waves and wrote up on the board relevant points about sound waves. While writing on the board he spoke about sound being the real-life example. He spoke of how sound is produced and emphasised on the fact that sound waves need a medium to propagate. They teacher used the textbook to discuss real life examples to prove the sound is produced though vibrations. He discussed these scenarios with the learners before moving onto the questions within the textbook regarding sound, sound and the effect of altitude, difference in the speed of sound vs light. There was still no evidence of the use of the ripple tank. An activity was given to the learners to do, questions 2. Further questions, question 4 and 5 were given to the learners to do and the teacher indicated that tomorrow in the lesson they will cover pitch, amplitude and the loudness of sound.

VSR questions

(Using the first video of Lesson 2)

Note to self: Skim through the lesson just for the teacher to briefly recall the events as a sequence.

23. At **4:50** a learner asked about the meaning of a vacuum. What do you think this indicates?
24. At **6:20** you asked one of the learners to come to the front to explain why sound travels faster in a solid than in a gas or liquid. What was your reason for this?
25. During **16:45-18:18** what do you observe yourself doing here?
    Evidence: The teacher makes the learners explain why…and then explains the answer after.
26. From **21:00-23:08** what do you observe yourself doing here?
    Evidence: The teacher refers back to Grade 9 to recall and initiate the learner's prior knowledge in order for them to think and answer the given question correctly by relating their prior knowledge to the given situation and scenario at hand. He uses a second example of the heating and cooling of water and the heating curve to further initiate the learner's memory.
27. During **23:45-25:48** a different type or different level of question was asked in the textbook. What level of question do you believe this is? and How did you approach this question with the learners?
    Evidence: Again, the teacher refers to a Grade 9 example in order to use the learner's prior knowledge so that they use this knowledge to answer the relevant.
28. At **31:00-33:34** you use a real-life example, one which they all were a part of. Give me your reasons for using such an example
    Evidence: The teacher uses sports day/athletics day as an example and asks what the timekeepers look for to start the stopwatches. He talks and explains about looking for the smoke or flash of the gun before hearing the sound which eventually allows the learners to identify that light waves move faster than sound waves. Note to self: At **34:20** the teacher uses another real-life example of seeing lightning and hearing thunder.
29. What representations did you mainly use in this lesson? What was the benefit of using this form of representation?
30. Which teaching style best represents this lesson?
31. In all of the lessons I observed you decided not to cover superposition. What is your reasoning for this?
32. What was your reason for not using the ripple tank in any of your lessons?

(Other prompts if needed: Was part of your reason due to time? Due to irrelevance? Due to end of term knowing that holidays are from tomorrow?)

33. Despite not using the apparatus are you confident in using the apparatus?
34. Had you used it – how would you have used it?

Note to self: Other prompts to ask

1. Which lesson/sections of a lesson were the learners most engaged?
2. What is your reasoning for this observation?
3. Which lesson best approached and dealt with the learner misconceptions?
4. What is your reasoning for saying this?
5. How will you be able to know whether your students understand the concepts you taught?
6. Out of all the concepts looking back, which concept did you find the easiest to teach and why?
7. Did you make any changes in the lessons that I observed compared to previous years and other classes or lesson plans? Why?
8. Do you believe what you planned out to achieve was achieved when coming to carry out the lesson or did you deviate from your planned lesson?
9. What changes would you make the next time you teach the same concept?

APPENDIX J: DIARY REFLECTION OF THE OBSERVATIONS AND THE SEMI-STRUCTURED VSR QUESTIONS FOR CRAIG

Lesson 1

The introduction of waves was done by reading definitions out of the textbook and writing them on the board. The textbook was definitely used as a resource. Learners would be given opportunity to respond but because they also had the textbook in front of them, they just read out the definition as stated in the textbook without understanding the concept. The following definitions were covered: *Pulse, medium, wave, oscillation, frequency, period, amplitude,* and *transverse wave*. After which a diagram of the amplitude and a pulse was draw on the board. The participant gave learners two questions (Activity 2, page 79 Questions 1 and 4) to complete at the end of the lesson. Other observations:

- The participant did not engage much with the learners making it more of a lecture-based lesson.
- The participant is quite reliant on the textbook.
- He tends to answer his own questions not giving the learners opportunity to think for themselves.

However, if learners have any questions, he does let them ask. He often chooses not to answer
them straight away rather obtaining all their questions first before responding.

VSR questions

(Using the first video of Lesson 1)

Note to self: Skim through the lesson just for the teacher to briefly recall the events as a sequence.

Clip 2:15 – 4:30

8. Looking back on the lesson clip, what did this lesson consist of?
9. You chose to start the introduction of waves with the definitions. What was the reason for doing this?
   Evidence: 01:50 – 03:00
10. I observe from the clip that you are very reliant on using the textbook. What is your reason for this?

11. A learner asked the meaning of one of the words used in the definition which was 'succession' – and you mentioned whether they had to go back to the English class. Does this often happen?

    Evidence: 22:24
12. Do you find in your class that English is a barrier to understanding concepts within the subject?
13. Do you feel that the learners were engaged in this lesson?

    Evidence: 13:46
14. Give me your thoughts on how you feel about the lesson you taught and the representation that you used?

Lesson 2

The teacher started the lesson by marking yesterday's homework which was to define amplitude and to draw a pulse on an axis with labels. The participant continued with definitions for *superposition, interference* and *constructive* and *destructive interference*. After the definitions were given the participant drew two separate diagrams to explain constructive and destructive interference. A further two questions were given for homework (Activity 2 page 81, Question 1 and 4)

Further observations:

- Todays lesson was also observed to be lecture based.
- I found it peculiar that the teacher chose to start teaching and discussing superposition, constructive and destructive interference after teaching the principles of amplitude and a pulse and before defining a wavelength, a crest and a trough.

VSR questions

(Using the first video of Lesson 2)

Note to self: Skim through the lesson just for the teacher to briefly recall the events as a sequence.

15. I noted that superposition was taught straight after defining a pulse and amplitude, which is what the homework questions were based on. What was the reasoning for this sequencing of topics?

(Using the second video of Lesson 2)

16. What do you see yourself doing in this clip?

Evidence 01:30-02:14 (A learner asked a relevant question: can many pulses interfere?

The teacher did give the answer of yes, it can and that it was based on the same principal.

The teacher also noted that it was at a level higher than Grade 10 but did explain what

would happen, depending on what type of interference it was.

17. Looking at lesson 1 and lesson 2 – which teaching style best describes lesson 1 and 2? Note to self: Ensure to have the learning styles available to the teacher.
18. Give me your thoughts on what you feel was the level of learner's participation during lesson 1 and 2?

Lesson 3a

The lesson involved the participant using the ripple tank. He did not seem prepared as he only began to put it together once the lesson had started. It took just under 8 minutes before the lesson commenced. The participant asked me to help him set it up. I only assisted in placing the stroboscope handle onto the stroboscope and the battery into the controller. He used the apparatus to explain frequency and wavelength quite well however, the participant seemed to be a bit hesitant on describing superposition. He set it up, illustrated it but he did not draw on the board not did he explain constructive and destructive interference but I believe it is because he himself could not see the phenomenon well. It was interesting to see that the participant illustrated the concept of diffraction. The learners seemed slightly confused and he indicated they had come across the idea of diffraction in Grade 9. He didn’t spend too much time on it, only illustrating it with a single barrier and then getting the learners to observe the effect when a narrow and wider gap was made using two barriers.

VSR questions

(Using the first video of Lesson 3a)

Note to self: Skim through the lesson just for the teacher to briefly recall the events as a sequence.

19. Was it the first time you used a ripple tank in your Grade 10 lessons?
20. You can see that instantly learners started congregating around the apparatus.…what do you think this indicates?

Evidence: 05:02- 06:12

Clip 11:10 -14:45

21. You ask the learners "what do you see/observe". Is it a technique you learnt from the training?
    Evidence: 11:10 -14:45
22. You demonstrated using the ripple tank the crests and troughs describing that the crests were the light lines and troughs being dark…did you know that previously or did you learn that from the training?
    Evidence: 11:10 -14:45.
23. You also then explained and demonstrated the relationship between wavelength and frequency. Do you think it was important for learners to see this relationship?
    Evidence: 11:10 -14:45.

(Using the second video of Lesson 3a)

Note to self: Skim through the lesson just for the teacher to briefly recall the events as a sequence.

Clip: 2:49 – 4:00

24. Learners start to ask questions. What do you believe this indicates?
25. You had one particular learner very interested in the lesson. He started asking higher order questions.
    Is he normally this interested?
    Do you believe he started asking these questions because he was able to visualise and link his ideas to the actual phenomenon seen?
    Evidence: He used the terms trough and crest and asked what would happen if one added another ripple bar with another motor on the other side of the tank. He even used terms such as arc (Evidence: Video 2, 12sec and 49sec) and asked for an example of a real-life situation using a barrier after diffraction was illustrated (Evidence: Video 2, 03:23).
26. You demonstrated wavelength and frequency, then you demonstrated superposition and then diffraction. Please explain the thought process behind this sequencing.
27. The bell rang which indicated the end of the lesson and yet some learners congregated around the apparatus. Why do you think this is so?
    Evidence: Video 2 - 05:17
28. Do you feel you should practise again before using the ripple tank again or do you think the training was enough to make you feel confident?

Lesson 3 b

The lesson started with the participant showing superposition again which was commendable as he realised that he did not observe it well in the previous lesson and so neither did the learners. After which everyone returned to their seats and he drew a transverse wave on the board with its labels. The teacher drew the whole diagram while the learners copied it after which he then started to interact with the learners about what was drawn. The teacher then continued with the definitions of a *crest, trough, wavelength, in phase* and *out of phase.* The participant acknowledged a misconception: that learners would label the amplitude from trough to crest. The teacher ended the lesson by giving homework. Other observations:

- I found it peculiar that the teacher decided to discuss the terms such as crest, trough, wavelength, in phase and out of phase after the demonstration. It would make sense if his reasoning would be because he wanted the learners to see the illustration first to understand what it looked like as a real-life scenario before seeing it in a diagram form.
- Because the teacher is so reliant on the textbook, the advantage is that he always used the correct terminology.
- The participant all in all is seen to use the ripple tank apparatus as shown during the intervention.
- All the important aspects and terminology were covered with the learners but the sequencing was peculiar and done in a lecture-based style.

VSR questions

(Using the first video of Lesson 3b)

Note to self: Skim through the lesson just for the teacher to briefly recall the events as a sequence.

29. The section of the lesson from **02:10 – 02:59** on superposition looked similar to what you were shown in the training ie: switching the light off, indicating where the phenomenon was best seen when looking at the apparatus. Is this something you learnt from the intervention?
30. During **02:10 – 02:59** a learner was confused about what they were seeing. How did you address this?

31. During **18:00-18:35**, what did you observe yourself doing here?

    Evidence: He indicated that he had acknowledge that learners would label the amplitude from trough to crest and not from rest position to either one thus identifying a problem area/misconception that learners have.

32. Considering the whole double, how did you address learners learning difficulties, if at all, during the lesson?
33. Did your learners enjoy the double lesson? What were the indicators?
34. Do you think that the learners learnt what you intended them to learn in the lesson?
35. Looking at lessons 3a and b which teaching style do you think this was more focused at?
36. Did you feel confident in using the ripple tank?
37. Would you have felt as comfortable using the ripple tank had you not had training on the apparatus?
38. I watched how you took the battery out of the ripple tank speed controller once you had demonstrated. Where you taught this during the training?

Note to self: Other prompts to ask

10. Which lesson/sections of a lesson were the learners most engaged?
11. What is your reasoning for this observation?
12. Which lesson best approached and dealt with the learner misconceptions?
13. What is your reasoning for saying this?
14. How will you be able to know whether your students understand the concepts you taught?
15. Out of all the concepts looking back, which concept did you find the easiest to teach and why?
16. Did you make any changes in the lessons that I observed compared to previous years and other classes or lesson plans? Why?
17. Do you believe what you planned out to achieve was achieved when coming to carry out the lesson or did you deviate from your planned lesson?
18. What changes would you make the next time you teach the same concept?

APPENDIX K: LESSON NARRATIVES FOR JESSICA

Sections	Time	Narrative and coding
1	0:01:33-0:05:35	The start of Lesson 1: The teacher tells the learners that they will be starting a new section called "waves". She starts by discussing the basics of the waves. She asks the following questions: What do we know about waves? What do we think about waves? (TS). To which the learners reply, by using their arms, what a wave represents or looks like in their minds (RP). She goes on to define *a wave* with a definition described in the work booklet, given to the learners. Using her arms and hands she moves them in a wave motion to make the learners aware, that when waves are being generated, it is the transfer of energy (RP)(TS). She discusses the term *medium* i.e. water, air and whatever it is travelling through (CS). She discusses the term *source* (CS). The teacher pauses to ensure learners have acknowledged the definitions and have highlighted the relevant information in their booklets (TS). The teacher is also using the booklet which prompts her to ask learners to list three everyday examples of waves (CS; TS; LP) to which the learners answer individually, in a popcorn effect, to indicate sound, light and coastal waves; therefore referring to water waves.
2	0:05:35 - 00:13:03	The teacher moves to the back of the classroom with the learners to demonstrate waves using a slinky spring (RP). The teacher tells the learners that they are going to observe the idea of waves, using the slinky spring (RP; TS). The teacher proceeds to make a wave, stating to the learners that to produce a wave, she is just going to move her arm up and down. She then asks the following: What can we see about this wave? (CT). She pauses and allows the learners to answer. Again, they all answer separately in a popcorn effect. A student answers: It moves from side to side. The teacher asks further: What do you mean by that? What do you mean by IT? (CT). She makes them aware of the fact that yes, the slinky goes up and down but the movement of the wave it

		straight/parallel. The teacher continues to leave the learners guessing and thinking. She further probes the learners through questioning and guidance (TS). The teacher then introduces the term "particles" (CS) indicating to the learners to imagine each particle as represented by each slinky curl (RP). She asks: Which way are the particles moving? (TS) The learners answer: side to side. The teacher does not correct them, rather tells them to watch an individual twirl (RP) while she produces another wave. She makes them aware that it is moving up and down and not left to right. She does not refer to the term - Transverse wave. The teacher then introduces the next type of wave (longitudinal) (CS) by showing on the slinky what it looks like (RP). Do we agree that this is a wave? Because there are bits that are being stretched and contracted, which is different to being stretched when moved 'up and down' rather than forward and back. The teacher goes back to producing a transverse wave and asks the learners to start describing the wave (LP)(TS). She allows the learners to answer; again individually. They describe it as continuous and fast. The learners do not describe what they are seeing very well so she rephrases the question: What do you notice about its shape? (LP)(TS). The learners describe it as having bumps, rounded bumps. The teacher makes them aware of how there are these 'bumps' which are being seen on one side and on the other side of where the slinky started. She asks the learners to come up with names for these bumps and a learner answers with the term 'crest and a trough' (LP)(TS). The teacher asks: How do I know where a wave starts and ends? Learners are left to discuss and answer (TS). A learner answers this in terms of the words "wave height" and "wavelength" coming up with the correct term on their own. The teacher ensured that the learners came up with the correct answers. The teacher then uses the slinky spring to show a pulse and a continuous wave and asks the learners to identify

		the difference between the two. A learner tries to answer and the teacher reiterates the learner's answer by indicating that what the learner is trying to say is that one waves has one 'bump' which is a crest and one 'bump' which is a trough (TS). The learners agree (TS). The teacher makes the learners aware of the fact that if one has more than one wave it just means the wave continues on and that they have more than one wave. The teacher recaps what it is they have established during the slinky spring demonstration (CS; TS) ie: the crest, trough, the beginning of a crest to a trough. The teacher then prompts the learners to give this idea of the beginning of a crest to a trough, a name, to which a learner answers: “wave height”. The teacher indicates that that is the incorrect term and another learner suggests “wavelength”. The teacher indicates that wavelength is the correct terminology. The teacher then uses the opportunity to discuss wave height (CS). She lets the learners determine the correct terminology used to describe wave height. Some say peak and others says amplitude. The teacher then indicates that the correct term is “amplitude”. The teacher moves on by using the slinky spring to carry out the same protocol described above but for the 'other wave', as she termed it to the learners (longitudinal). She indicates that there are no crests or troughs and starts by asking which way the particles are moving (CS; TS). The learners answer, forward and back, also left and right. She compared it to the 'other wave' (transvers wave) where the particles were moving perpendicular to the way that the wave moves. She illustrated the longitudinal waves again using the slinky spring (RP) and immediately a learner indicates that the particles are moving parallel. Without being prompted a learner indicates that what is being observed is a longitudinal wave. The teacher then asks at this point what the 'other one' is called by demonstrating it again with the slinky spring (RP)(TS). In chorus they say latitudinal wave.

		The teacher laughs and indicates that this is not a geography lesson (LP). A learner then says a 'transverse wave'. The teacher indicates that the learner is correct. The teacher then asks the learners: do we agree that when there is no wave, we call this (showing with her arm along the stretched slinky) the 'rest position', it is like it is at rest? (RP; TS). The teacher indicates another term for it which is equilibrium. A learner answers by indicating that what the teacher has said makes sense (LP). The teacher further explains that from the rest position, if there is a 'crest one' is comparing it to the 'rest position' and if there is a 'trough' one is comparing it to the rest position and so the amplitude is how far away from the 'rest' position it has moved.
3	00:13:03 – 17:54	The learners return to their desks and the teacher explains that they are now going to discuss waves further through a diagram drawn on the board (CS; TS). The teacher reads from their booklets that there are two types of waves. She indicates to the learners that she has shown the learners the two types of waves using the slinky spring (RP). She makes them aware that there are a lot of animations available online for the learners to use and to look at if they wish (RP). The teacher starts with the discussion on the 'transverse' wave. She indicates that the second type of wave is the 'longitudinal' wave but that they will be mainly focusing on the 'transverse' wave. She indicates to the learners that they will need to identify a 'longitudinal' wave and label parts of it (CS). From the booklet she reads and discusses the following: - The disturbance of the transverse wave. She elaborates that it means a 90-degree movement of the particles to the direction of the wave and reminds the learners that they observed it through the movement of the individual slinky spring coils (LP). - The teacher then talks about how not all waves need a medium i.e. Light that moves through space and that space is a vacuum because there are no particles (TS; LP). She discusses the movement of air or water particles and that what they saw through the illustration was the slinky spring coils, as particles. She thus discusses that transverse waves can be propagated without a medium (CS). A learner asks the teacher to reiterate what a medium

		is. She explains that it's the environment that waves move through. - She refers to the graph in the booklet on how a transverse wave is normally represented and she then starts drawing it on the board (RP). While drawing the diagram the teacher explains what she is drawing ie: Axes, positive and negative (opposite directions); disturbance on one axes; crest and trough. She refers to the term *peak* as an alternative to crest (LP).
4	17:54- 25:46	The teacher refers to what the learners called the wave being from the start of the crest to the end of the trough and indicates that she will correct their use of terminology and therefore use the word pulse (LP). She explains it as one wave cycle. The teacher discusses particles again and the way they move, i.e. how some are about to go up and others that are about to go down. She indicates that particles are not all in the same movement (thus in and out of phase but doesn't use that terminology). The teacher tells the learners to be careful when answering questions about a wave and a wave cycle. When a question refers to a wave; it refers to the whole diagram that has been drawn referred to in the question and is not just referring to a wave cycle, which is one pulse (WDT; LP). The teacher then moves on to talk about the wave height, using the terminology that the learners originally used (CS; LP; TS). The teacher starts to discuss the idea of particle movement from the rest position to the highest point. She asks the learners to indicate the term used for this, leaving the learners to answer (LP; TS). One learner answers using the term amplitude (TS) which the teacher indicates is correct. The teacher explained that the learners used the phrase length of the wave when observing the wave using the slinky spring (CS; LP; TS). She asks a specific learner to name what he thinks the term is going to be (LP; TS). The learner answers "wavelength". She mentions that it is how long one cycle is. She introduces the Greek symbol of lambda (CS) and indicates that it represents one wavelength, the length of one pulse. A learner asks the teacher if a pulse

		and wavelength are not the same thing. The teacher indicates that a wavelength can be from crest to crest, trough to trough or halfway up to halfway up of the next point (CS; LP). She explains that a pulse is describing the image drawn on the board involving one crest and one trough and that wavelength is the length of that wave cycle as a distance (LP). Another learner asks for clarification between a pulse and a wave cycle. The teacher goes back to refer to what the learners saw on the floor with the slinky spring (LP) and then draws another wave cycle in another colour on the board (RP) and names it a 2nd wave cycle. This clarifies the learner's confusion (WDT; LP). The teacher indicates that the starting point of a wave is where the source is (CS). A learner asks: how do you measure where one pulse ends and another starts? The teacher explains either through measurement using a diagram but otherwise using a measuring machine or device or if one could take photos and snap shots, then it would be possible to measure it (CS; WDT). The teacher feels the need to redefine wavelength and indicates that it can be measured from different points along the waves but as long as you measure between two consecutive points that are in phase (TS). A learner indicates that she is confused about a pulse and one wave cycle. She asks if they are the same thing. The teacher indicates that they are (WDT; LP). The teacher again reiterates that if one is drawn it is referred to as a ‘pulse’ and if many are drawn consecutively then it is referred to as ‘wave cycles’ because there are many pulses being repeated (WDT; LP; TS). Another learner asks if a wavelength can be defined as the length of a pulse but the teacher says not to use that definition and indicates that the booklet contains the correct definition. The teacher reiterates that the wavelength can be from peak to peak (TS). It is the same thing but by changing the point of reference; as long as they have the same starting points it will give the wavelength i.e. hence one uses the terms two consecutive points.
5	25:46 – 28:00	The teacher refers to the booklet in order to continue with the definitions of crest; trough and particles in phase

	And 00:00 - 05:50 of the second video of Lesson 1.	allowing the learners to fill them in, in their booklets (CS). She elaborates what 'in-phase' means by stating that it is particles going in the same direction and which have the same amplitude, meaning they have the same disturbance (CS). She discusses amplitude being from the rest position and that it is the maximum displacement from the rest position and not from rest position to halfway up the wave. She reiterates that it has to be from the top of the crest to the rest position or from the lowest point of the trough to the rest position (CS; WDT; LP). Points in phase is now discussed with the learners. The teacher uses two colours to illustrate points in-phase on the diagram on the board (RP) i.e. that they are both moving up in the same direction and with the same amplitude or disturbance. She then discusses 'out of phase'. The teacher organizes two learners to stand in front of the class to use their hands and arms to form a wave to represent being in-phase (RP). They do not do it 'in phase' so the teacher suggest that they face each other to do mirror imaging and thus allowing both of them to see and as one hand raises of the one learner, the other learner does the same thing (RP; CT). The teacher continues to talk about 'in phase and out of phase' of two waves but pertaining to one wave with the same direction, and amplitude. She then elaborates and discusses with the learners that particles can be in phase but be on different waves (CS) ie: getting learners ready for the term "superposition" but she doesn't say this. She connects the idea of in-phase to water waves explaining how learners when looking out at sea can observe that all the crests are in phase with each other and how all the troughs are in phase with each other (LP).
6	05:50 – 12:45	The teacher talks about the unit for amplitude and that wavelength is also measured in meters but that wavelength units can be converted to smaller units such as nanometres or millimetres. This would involve having to incorporate scientific conversions. At this point the teacher makes learners aware of the term's frequency and period (CS). The teacher refers to how the learners previously referred to the speed of the wave when they were observing the wave, using the slinky spring illustration (LP). She explains that she is going to

		now use the term frequency and asks the learners what is meant by the term ‘frequency’(CS; LP). A learner answers by saying that it means 'how much'. Teacher asks: how much what? (TS) Another learner answers: 'how many times you have it'. The teacher further probes asking: how many times you have it in what? (TS) A learner answers: How often something happens in a period of time (TS). The teacher indicates that when talking about frequency it is related to a specific time. How often that cycle happened per month or how often you are paid per week etc. The teacher links everyday examples of the term frequency (CS; LP; TS). The teacher moves on to relate frequency to waves and asks the learners: what do you think we are going to be talking about? (LP; TS). A learner answers: How many waves pass in a certain amount of time. The teacher refers to the diagram that was previously drawn on the board and is still seen on the board (RP). The teacher shows the learners using the diagram that if one has one wave cycle then a next wave cycle, all happening in one second, then they have two waves happening in that period of time i.e. one second. The teacher further defines frequency as how frequent that wave is passing a point in a certain amount of time. She reads the definition of frequency from the booklet. The teacher then talks about the unit of frequency; Hertz (Hz) and that it is named after someone. Thus, one must use a capital H when writing Hz (CS; TS). She further discusses that it’s the number of waves per second and is thus referred to as 1/s or s^{-1} (CS). The teacher moves into introducing the sub-ordinate concept of period (CS). She asks the question: If there is only one pulse, how do we know its speed then? (TS). A learner answers that it is how long it took to make that pulse. The teacher explains that period is when one talks about how long each wave cycle is. The teacher makes sure that the learners understand that they need to know the difference between frequency and period (WDT; LP). The teacher further cements the difference between the two by explaining another way of looking at each (LP; TS). She says that with the one (frequency) one does not know how many waves occurred per second. However, for the other (period) it is the other way around.

		One knows how many waves occurred but not the time they took to occur. The teacher reiterates and pleads with the learners that they should not confuse the two (LP; TS). She states that she believes some of them will because it is one of the easiest things to confuse (WDT; LP). The teacher refers to the booklet to further discuss the definitions of frequency and period. The lesson ends and the teacher concludes by asking the learners to go over the definitions for homework knowing that they have a test to learn for, for the following day.
7	4:31 – 17:33	The start of Lesson 2: The teacher indicates that so far they have covered the wave equation, that they have practised questions using the equation and are able to determine the speed of the wave, the frequency of the wave, the period of waves, the wavelengths and know what the amplitudes are (CS, LP). She continues to discuss that waves behave in a certain way for example, they interfere causing interference. She asks the learners what it is they understand by the term interference? (TS) A learner suggests it might be stopping something, interrupting something. Another learner says that it is when something is resisting something. The teacher indicates that she is going to show learners interference but basically it is when waves start clashing. The teacher then indicates to the learners that they will be covering reflection and in a lot of detail. She asks the learners what they understand by the term reflection (TS). A learner answers: a mirror, it bounces off and reflects in a certain direction (LP). The teacher then indicates that there is a term called refraction. She uses a real-life example of jumping into a swimming pool where an object appears to be in one place but when one jumps in it is a lot deeper than one thinks it is. (LP). She uses another example of being at a restaurant where a straw is placed into a glass of water and appears disconnected. She indicates that it is due to a property of refraction and that the learners are seeing refraction happening but are not aware that it is refraction (CS). The last phenomenon that is briefly discussed with the class is diffraction. The teacher uses the example of when one goes to bed at night and has a light on

		in the passage and that when the door is left slightly open, the light on the floor seems to make a *v* shape and is seen to spread into the room (LP; TS). She states that these are all examples of how light waves act but that the same phenomena happen with water waves. She also then proceeds to use sound waves as an example. She further suggests that if the classroom windows were closed but the door was slightly open, then someone standing on the other side of the classroom wall, would be able to hear her speaking (LP; TS). She makes learners aware that the term "bending" is the wrong term to use and that the waves go around an object (CS). She indicates that during this particular lesson they start to observe waves in a practical way (TS). The teacher made the learners stand up to do the Mexican wave as a whole class and then all together as one row (RP; TS). She did this to explain the idea of wavefront, with particles moving with the same motion (TS). She incorporates this and relates it to water waves and that not just one water particle is seen to move. She explains to the learners that in water one cannot see individual particles move, but sees them move collectively, exactly how the class behaved during the Mexican wave (RP; TS; LP). To further cement the idea, the teacher further explains that many water particles move with the same motion which is why at the ocean one can see the whole wave crest coming towards oneself and in the same way see the wave when it dips (LP;TS). She explains to the learners that when they had been drawing waves on the board or in their books, they were drawing 1x 2D wave but it can in fact be seen as a 3D wave with many of the waves lined up next to each other (LP; TS). The teacher indicates that when all the waves or crests line up it is called *wave fronts*.
8	17:33 – 21.33	The participant started to illustrate wave fronts using the ripple tank apparatus (RPRT). She introduced it as the ripple tank to the learners and explained what it does. A learner indicated that it makes ripples. When the teacher switches on the light and motor of the ripple bar the learners are very intrigued. Commenting on the

		phenomena of the apparatus. The teacher indicates to the learners to look under the tank on the surface of the desk and not directly at the water in the tank. The first illustration carried out by the teacher was through generating ripples using the ripple tank to illustrate waves and thus wave fronts move across the tank (RPRT). She links the 2D drawing that they had previously done on the board and in their books to what they were now observing. She explains that they are seeing a whole bunch of waves together thus producing 3D wave fronts when all the crests are moving all as one next to each other across the tank, the same with the troughs. (LP; RPRT)
9	27.35- 21:33 and 00:00 - 01:33 of the second video of lesson 2.	The teacher moves onto using the ripple tank to illustrate reflection with some interference. Before starting the illustration, the teacher makes the learners aware of the presence and observation of the darker lines and lighter lines when looking at the projection of the water on the desk below the tank (RPRT; CT). The teacher then asks them to think which it is they believe represents the crests and the troughs i.e. which is represented as the lighter lines and which is represented as the darker lines (CS; LP; TS). The learners try to guess, but the teacher does not elaborate any further. The teacher then discusses reflection, occurring at an angle. She explains that it is easier to see when reflection happens off something at an angle because if it is 'direct' reflection it is not easy to see, as everything is aligned. The teacher places the barrier in the tank, as done in the training, at a 45-degree angle, to illustrate reflection (RPRT). She illustrates it first with one pulse by pushing the ripple bar down with her finger. She illustrates it again using a ruler as the barrier and then again with the barrier parallel to the ripple bar. She discusses the ways in which reflection is seen in all three scenarios. The teacher moves onto Refraction. The teacher places the Perspex prism under the surface of the water as done in the training (RPRT; TS) and adds more water so that water covers the prism. At this point the teacher refers to a previous activity question that the learners were getting confused about which involved frequency

		and refraction and why the speed and wavelength was changing but the frequency remained the same (LP; TS). She explains that with the prism in the water it is making deep and shallow water. She makes the learners observe the effect under the ripple tank base. The effect is not easily seen because there is too much water in the tank.
10	01:33 – 5:45	The teacher takes the straight longer metal barrier again and places it at 45 degrees in the tank to show reflection again (RPRT). A learner asks what the squares are that they are observing i.e. like a crisscross effect. The teacher indicates that it is interference. She then says that one has the dark lines (which they still haven't identified as crests or troughs) which are "now fighting" with the light line because they are moving in different directions. At points the lines will be competing with one another thus "sometimes will agree and sometimes they will disagree" (LP; TS). The last illustration is diffraction. The teacher makes a gap using the two longer metal barriers and switches on the ripple tank controller (RPRT). The learners display enthusiasm. The teacher asks the learners why they think they are still observing waves behind the barrier despite the barriers being in the path of the waves. The teacher allows the learners to think and answer on their own in a popcorn effect. She then indicates that one would think logically that because there is a block in the way it would only go through the gap. The teacher lets the learners absorb the information and to continue to discuss it. The teacher then takes the barriers off from the tank and places them above the surface of the desk next to the tank and asks the learners that if she were to pour water or rice over this and through the gap where would they see rice at the end of the exercise? (RP; TS). She continues: One would immediately assume that it will all be blocked out by the barriers and only be seen piled up under the gap. She then points to the ripple tank to refute this aspect. The learners are given a break.

11	14.40- 5:45	After the small break, the teacher sets up the apparatus to illustrate circular waves using one ball attached to the ripple bar (RPRT). The teacher illustrates refraction again using circular waves and shows the learners that there is a difference in wavelength of the waves that are above the Perspex prism compared to the waves on the outsides of the Perspex prism. She continues by showing the learners reflection, while still using circular waves but doesn't explain anything further. She very briefly also shows diffraction with circular waves and does not elaborate on it. The teacher sets up the ripple tank by removing the ball and uses the curved barrier to illustrate reflection, placing the curved barrier as a concave shaped reflective barrier (RPRT). She asks the learners, before illustrating it: what they think is going to happen (TS). A learner answers by using her arms that waves will go into each other. The teacher then turns the curved barrier around to be convex shaped reflective barrier. As a chorus the learners say that 'they' will go out. The teacher then illustrates it to see if they are correct in their predications (RPRT). What is observed is exactly as the learners predicted.
12		Some time was left of the lesson so the teacher allowed the learners to 'play' with the different pieces of the ripple tank and the ripple tank (TS). The teacher does not allow the learners to just randomly mess around by putting the barriers etc into the tank without predicting what they think will happen (TS). Only once the learners have predicted what they think will happen, does the teacher allow the learners to carry out the illustration to see if their predications are correct.
13	00:00:11 - 03:16	The start of Lesson 3: The teacher asks the learners if they remembered the four different phenomena of waves previously discussed in the lessons before today's lesson (LP; TS). Different learners answer by saying refraction; reflection; inference and diffraction. She then asks: what do we think about when we think about reflection? (TS) Learners answer, which the teacher repeats – "like a mirror, something bouncing off and

		moving in another direction". She asks the same question about refraction: the teacher reiterates that it's the one where they change the medium by changing the depth where they observed a change in speed and wavelength. She then asks: what do we think about the term 'diffraction'? (TS). The teacher leaves the learners to answer. They do not reply and so she recaps on the phenomena that they had previously observed and had already discussed within this lesson to stimulate their thoughts on what they have not yet mentioned. A learner then mentions that it is the "Wi-Fi sign" one (LP). The teacher agrees and reminds the learners as to what they observed when using the barriers to form a gap/slit and that it spread behind the barriers. The last one discussed is interference. The teacher asks how the learners observed the effect of interference (TS) and a learner describes it by using the term "blocks".
14	03:16 –15:31	The teacher indicates to the learners that they will not be covering interference in too much detail because it is not entirely important to know for the matric paper (CS; TS). The teacher introduces the concept by indicating to the learners that there are two types of interference and that they need an understanding about when interference happens in a 'good way' and a 'bad way' (CS; LP; TS). She asks what learners understand by the term 'good interference' and what it will do to the waves (TS). A learner answers by saying that it may make them bigger (TS). The teacher agrees and indicates that it will increase in size. The teacher used everyday terminology to initiate learner thinking by saying "If I interfere in things in a good way what do we call it?" (LP; TS). The learners answered in chorus saying "constructive" (CS). The teacher briefly explains verbally about constructive interference using two pulses. The pulses would combine and get bigger. The teacher moves on to the other type of interference. She asked, "When I interfere in a bad way what it is called?" (TS). A learner indicates that it is when "we get smaller". The teacher brings in how it can be cancelled out for a moment. She then asks them to give it the right term by thinking of the opposite to constructive interference. No one answers

		and she supplies the correct term as destructive (CS). At this point a learner takes it quite literally and asks the teacher if the destructive interference is a bad thing and if the constructive interference is a good thing. The teacher explains that it is just an analogy to help learners understand that bringing a person up through something constructive is making them 'bigger' to illustrate making waves bigger and that destructive, which is a bad thing in life, is making the waves smaller (LP; TS). The teacher goes to the back of the classroom to illustrate the concept using a slinky spring to generate pulses (CS; RP). The teacher gets the learners involved by getting two learners to hold the slinky spring on either side and to stretch it out. She reminds the learners about a pulse (LP) and a learner uses the slinky to re-illustrate it as a reminder to the learners. She asks one of the two learners holding the slinky to generate two pulses with the one after the other. She explains that the two pulses seen do not affect each other because they are going the same speed and in the same direction. The teacher comments on the beauty of seeing the slinky spring when waves are coming from different directions. She explains that the waves have different sources and thus different directions. She asks the two learners holding the slinky spring to each generate a pulse to each form a crest. She states that the two waves would be from different sources and would be moving in opposite directions. The illustration is not effective but the learners continue to try. Eventually, the teacher realises that it is being illustrated too fast to observe. She asks the learners what is happening? (TS) A learner answers: They meet and go back (WDT). The teacher then further stimulates the learners thinking by asking the following: So, what happens when they meet? (TS). The learners still believe that it bounces back by stating as their response to the teachers question that "the waves bounce back". The teacher pauses (WDT; LP). The teacher therefore asks one of the learners who is holding the slinky spring to illustrate one pulse again and shows the

		learners that the pulse continues along the slinky spring all the way to the end (RP). She then asks why when there would be two pulses from opposite ends that they think it would now bounce back? (TS). A learner answers that it is because there are two and so they bounce off each other. On a side note, a learner talks about seeing reflection in the slinky spring and the teacher agrees. She also tells the learners that they are observing it because a learner is holding the one end and it will naturally reflect off the learners' hand. She tells the learners to ignore the reflection for now (LP; TS). The teacher then tells the learners that they should be observing something when the pulses meet. She allows the learners to observe the effect again and to try to explain what it is they observe. The learners battle to answer and the teacher asks the two learners holding the slinky spring to carry out the illustration again for the learners (LP; RP; TS). The teacher asks again: what did we see in the middle? (TS) Still the learners do not answer and she suggests that the slinky is made to be less stretched. She reminds the learners that it happens quickly. Eventually a learner says, "there were two that became one", which the teacher repeats. She then asks them to compare the two that they see to the one that they observe. She further asks: What can we say about the one in the middle compared to the one on the sides? (TS) A male learner tries to explain, but he also states that when there is one it’s a good interference and when there is none it is a bad interference (it is the same learner that asked earlier about 'good' and 'bad' interference) – the teacher indicates his wrong thinking (WDT; LP; TS).The teacher eventually explains to the learners that there is a bigger wave in the middle because they are joined. The learners that are holding the slinky spring try use it to illustrate the concept again but off the floor. The learners seem to see it better illustrated this way (RP). The teacher then explains that the crests on either side are combining and as a result getting a new crest that is the same height as the two pulses combined.

		She indicates that what they observe is constructive interference which is seen better at the crests and troughs. Crests to make bigger crests and the same for the troughs. The teacher goes back to what the learners were stating earlier regarding the term 'bouncing back' (LP). The teacher goes straight into explaining that the pulses are not actually bouncing back and are in fact carrying on through. She explains that they are only appearing to be bouncing back because the pulses return to the same size that they were. The teacher then asks what they think the difference is, in terms of destructive interference (TS). A learner says, "moving the slinky in opposite directions", while indicating on the floor that the one learner must move the slinky up and the other must move the slinky down. The teacher elaborates and indicates that instead of a crest meeting a crest;one would introduce a crest meeting a trough. She goes back to their new understanding about how a crest meeting another crest gets bigger. She then asks: what will happen when it is crest to trough?(TS) A learner straight away says that they will even out and become flat. The teacher allows the learners to illustrate the concept using the slinky spring but it is not easily seen. They do all acknowledge that there is not a large crest in the middle, as before. After doing the illustration using the slinky spring "sideways" along the floor, they illustrate the idea of using the slinky spring off the floor (perpendicular to the floor). Gravity is against them and they realise it will not work. The teacher tells them that they are meant to see 'cancelation' which carries on after waves meet.
15	15:31 – 25:28	The teacher re-explains the concept through a drawn diagram on the white board (RP). She begins with constructive interference and two pulses using two different colours and timeline segments. She draws the before, during and after illustration of constructive interference. She uses mathematical values in the diagrams. The teacher brings in the idea of water and uses the term 'ripple' or 'wave' (LP; TS). She explains that when the ripples or waves meet, they make bigger waves or ripples and before they meet, smaller waves. The teacher

		then does exactly the same diagram to explain destructive interference (RP). The teacher makes the learners aware that the waves carry on and that they do not stop at the point they meet (LP; WDT). A learner asks the teacher while referring to the diagram, illustrating constructive interference using crests, if it would be the same diagram with troughs. The teacher indicates that it would. Another learner identifies that with constructive interference one 'pluses' the mathematical amplitude values and with destructive interference one subtracts the values. The teacher reiterates using different mathematical values for destructive interference to indicate what would happen when it is not a total destructive example. The teacher reminds the learners that they only need to know understand what is going on in this concept (CS). Furthermore, waves that combine will have increased amplitude. If they meet but have crests and troughs then their amplitudes will decrease or cancel out. The teacher puts up a simulation using wave A (blue) and B (red) which are of the same speed and have the same amplitudes and wave C which is the combined wave in white (RT). The simulation is used to illustrate a crest that meets a crest forming another crest. The resultant crest is bigger and when a crest meets a trough, the resultant pulse gets small or totally destroyed. The teacher stops the simulation at each different interference (crest with crest; trough with trough) and then stops it at complete destructive interference (crest with trough with same amplitude). She then makes the simulation show wave B to have a bigger amplitude to illustrate that when a crest and trough meet, total destructive interference does not occur (RT). She indicates that she is not going to change the wavelength because it will make it too complicated (WDT, CS, TS).
16	25:28- 26:52	The teacher states that interference but of water waves will be seen later using a ripple tank. She states that

	video 1 of lesson 3 + 00:00-13.26 Of video 2 of lesson 3	they have not yet answered the question: what the bright or dark lines represent** (LP; TS) She promises to illuminate this at a later stage. While still looking at the simulation the teacher asks them to choose, for illustration purposes what they believe the lines will represent (LP; TS). The learners choose the bright lines to represent the crests. The teacher then asks the learners: When the crests combine, what do they think will happen to the brightness of the lines? (TS). A learner answers and the teacher repeats her answer, stating that they will get brighter. She asks in a similar manner: if the troughs are then the darker lines, what will happen when they meet? (TS) In chorus the learners say, they will get darker. The teacher indicates that this is what they will see in the ripple tank. The teacher starts to illustrate interference using the ripple tank at the back of the classroom (RPRT). The teacher indicates that using the ripple tank she is going to illustrate interference. She first illustrates interference using the option of the longer metal barrier placed at an angle (CS; LP, RPRT). She indicates that the learners should not only see waves moving towards the barrier but that they are also interfering with those that are reflecting off the surface of the barrier. She produces a pulse using the ripple bar. She asks if they can see the "cubes" indicating interference due to reflection (TS). She does the same but with the motor, to illustrate the same principle but using waves. A learner points out the interference and reflection. The teacher uses this opportunity to discuss the light and darker lines because of the interference of crests being higher and troughs being lower (CS; LP). The teacher agrees that the learner is interpreting it correctly and that where the crests meet bigger crests form and the same with the troughs. She also indicates that according to the learners, the crests would then be the bright lines

		which form even brighter lines when they interfere and darker lines when the troughs interfere. A learner then comments: "according to science". At this point the teacher indicates that it may be the opposite effect according to science but that she will prove it to them later when they cover refraction in more detail (LP, WDT, TS). She leaves the learners intrigued by this statement, not correcting them or indicating if they are correct, she moves on (TS). She asks if the learners see a change in the intensity of the light and dark "spots" and explains that it is as a result of the interference, just discussed on the board using the diagram and simulation (section 15) (TS). The teacher asks: what do you think would happen if one use circular ripples? (CS; TS). No one answers and she sets the tank up to illustrate it. She asks: what is going to happen to the waves when they start to interfere as circular waves? (TS). She indicates that she will do a pulse to allow the learners to think and predict before illustrating the effect using wave fronts (RPRT). A learner says that they will interfere. The teacher says: yes, but how? She pauses and allows the learners to think and predict. A learner suggests hypnotism – although very off the topic. The effect of the ripples made her think out the box. The teacher made the learners aware that it was not hypnotism and made them focus again. Another learner says that the circles will interfere with each other. The teacher indicates that again they should see the bright and dark lines but they are not going to be squares as seen with reflection off the barrier and that the wave pattern will be something different (LP). She then sets the ripple tank up with two balls to illustrate the effect (RPRT). While trying to do so, the battery of the controller became flat. The teacher showed the effect manually pushing the ripple bar down to illustrate the principle, until the battery was changed (RPRT). She made the learners aware of the sections where the waves seemed brighter and darker and where they seemed to disappear and cancel each other out. The motor is then used and the teacher points out that the areas

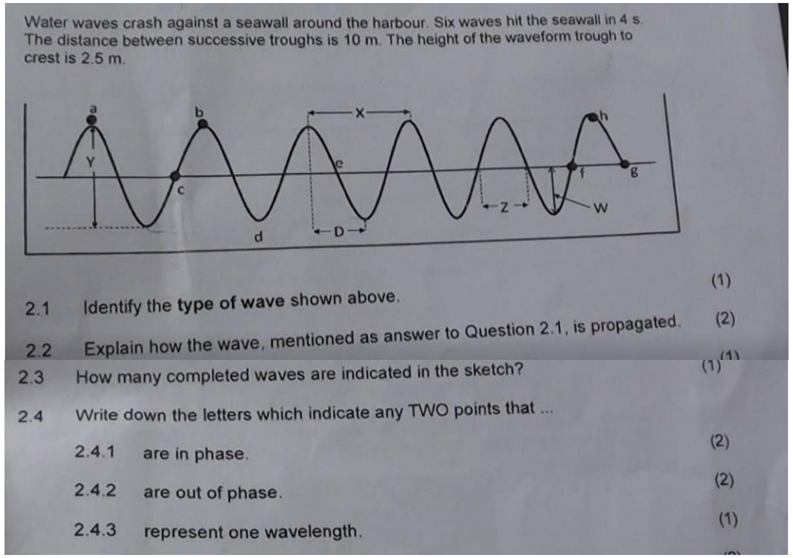
		of interference are more like dots and therefore there are dots that are lighter and others that are darker. The teacher makes the learners aware of lines coming from the source (balls) and then asks them what they think is happening at those points? (TS) A learner uses the term arcs and says that they continue on. Some learners are battling to see the effect and the teacher uses her finger to show the learners the areas of complete destructive interference again (RPRT; LP) and refers to them as grey lines. She asks the learners again: what is happening? (TS) A learner answers that they are cancelling out. The teacher then asks: why do you think they are cancelling out? (TS). The learners battle to answer her so the teacher goes back to the foundational ideas. She asks: how do we see waves? (LP; TS) They answer by saying that there are crests and troughs. She then asks: how are they seen in water? (TS) The learners answer that it is through light and dark lines (LP). She then asks: So then, if there were no waves? (TS). The bell rings to indicate the end of the lesson and therefore the teacher is forced to tell the learners that the grey lines represent areas of total cancelation. **The bright and dark lines are the projection of the water waves on the white table underneath the ripple tank.

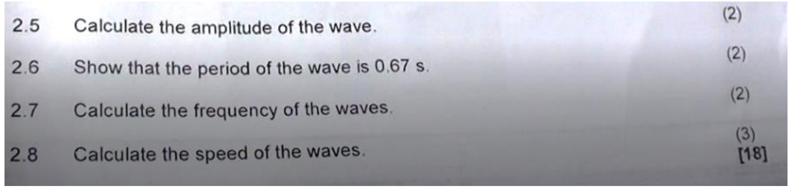
APPENDIX L: LESSON NARRATIVES FOR TSHUMA

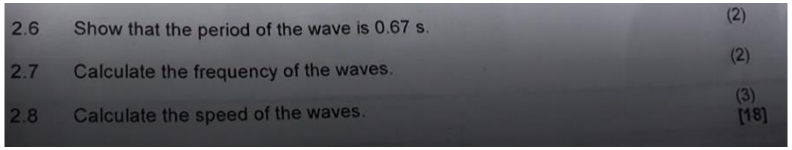
Sections	Time	Narrative and coding
1	00:00 – 11:22	Start of lesson 1: By writing on the board using the formula, $v = f \times \lambda$ the participant explains to the learners, that wave speed is equal to frequency x wavelength, with wavelength written as 'lambda' (CS). He asks the learners if they are all together? (CS; LP; TS) The teacher speaks about the first type of wave being the transverse wave and that he has covered 'amplitude'(CS). He asks the learners if they remember what 'amplitude' is? (LP; TS) Learners answer all at once and he stops them in order to tell them to raise their hands (TS). A learner answers that it is a displacement of particles in a medium. The teacher re asks the question and allows the learners to answer (TS). A learner answers with the correct definition. The teacher reminds the learners that they have covered the concept of wavelength and asks a specific learner to give its definition (CS; LP; TS). The learners are heard making a noise and the teacher asks them to be quiet (TS). The learner answers correctly. The teacher reiterates that the wavelength can be measured from successive crests or troughs and can also be from one point to another point that is in phase (LP; WTD; TS). He tells the learners not to forget what they have just discussed, because they will see this type of question in examinations. (LP). The teacher further reiterates that the wavelength is not always measured from crest to crest and trough to trough (CS; LP, WDT, TS). He moves on to discuss the formula of $v = f x \lambda$, while writing on the board and reminds the learners that they have already done calculations (CS; LP). The teacher then told the learners that sometimes they will be asked to calculate the frequency, without being given the speed and the wavelength of the wave (CS; LP; WDT; TS). He asks the learners what they would do in such a case (TS). A few learners answer that frequency equals the number of waves divided by the time.

		The teacher writes it on the board. The teacher then revises the idea that frequency can also be calculated by putting *1/T* which represents one divided by the period of the wave (CS). The teacher then writes down, *T* = and asks the learners how they will work out *T* if they do not have the frequency (TS; LP). They discuss that they will use time divided by the number of waves and that T is also equal to *1/f* (CS; LP; TS) he writes these on the board. The teacher indicates that they are going to look at a past paper and its questions during the current lesson, using the formulae just discussed and that the questions will be found on the handout given to the learners (CS; TS). He carries out the first question with the learners but first gives them one or two minutes to read through the question. The past paper questions done during this lesson can be seen below. The teacher reads out the main question information. The teacher reads out the question from the question paper, "Identify the type of wave shown above" and asks the learners to raise their hands if they know the answer (TS). A learner responds by stating that it is a transverse wave. The teacher asks him to explain "why?" (TS) and that it leads to the next question of how the wave is propagated. No one answers to begin with and then a learner answers but incorrectly by stating that it has a trough and a crest. The teacher asks again how the wave is propagated and how a particle moves. The learner answers by saying: the disturbance is perpendicular to the propagation of the wave. The teacher asks the learners what the keyword will be in that definition (TS) and highlights that it is the word ‘perpendicular’ and that it is- nighty degrees. He further reiterates the definition as the disturbance of the medium being perpendicular to the direction of the wave (TS). He asks the learners if they are "fine" (TS) and then points out that they are going to start fighting over the next question. The teacher reminded them that they

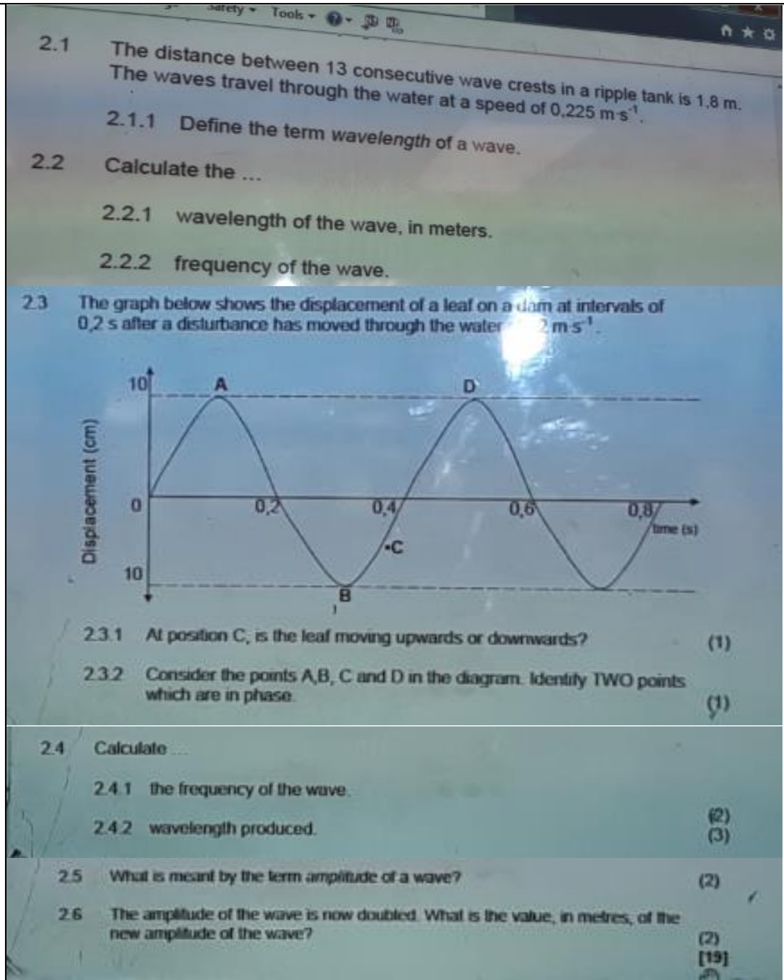
		previously had a similar question and that they struggled to identify the number of waves (LP; WDT). The teacher reveals that he is aware that this is a challenge (WDT, LP). The teacher says that they should take their time to answer the question (WDT; TS). He asks the question again and the learners answer in chorus (TS). Some learners answer with "five waves" others answer that there are four waves. The teacher discusses the question with them while they follow him and his instruction while looking at the diagram (TS; RP). He shows that there are five-and-a-half waves. There is a huge class discussion over this, but the teacher allows this discussion to continue (TS). The teacher then indicates to the learners that alternatively, instead of measuring from crest to crest, the learners should start measuring from the beginning of the wave (LP; WDT; TS). He says this twice over. Eventually, the learners agree that there are five-and-a-half waves. The teacher again asks if the learners are "fine" (LP; WDS; TS). He moves on to the fourth question (Question 2.4). He allows the learners to answer 2.4.1 and 2.4.2 but discusses 2.4.3 with the learners and asks then "why?" (TS). Learners

		answer saying that the answer is from one crest to another crest. The teacher reiterates that it's from two successive points or two consecutive points (CS; LP; WDT; TS).  Water waves crash against a seawall around the harbour. Six waves hit the seawall in 4 s. The distance between successive troughs is 10 m. The height of the waveform trough to crest is 2.5 m. 2.1 Identify the **type of wave** shown above. (1) 2.2 Explain how the wave, mentioned as answer to Question 2.1, is propagated. (2) 2.3 How many completed waves are indicated in the sketch? (1) 2.4 Write down the letters which indicate any TWO points that ... 2.4.1 are in phase. (2) 2.4.2 are out of phase. (2) 2.4.3 represent one wavelength. (1)
2	11:23-14:35	The teacher now moves on to Questions 2.5. The teacher revises the definition of an amplitude, stating that it is from rest to the peak of the wave (CS; LP; TS). He asks the learners to look at the diagram (RP) and to indicate what it is that they see (TS) and what information they see, that would assist them in calculating the amplitude (LP; TS). He asks a particular learner to answer (TS). The learner answers by saying that they have been given the information of how far it is from one crest to one trough. At this point the teacher starts to draw a diagram of a transverse wave on the board (RP) to indicate what the learner has just stipulated (TS). He labels the crest and trough and a dotted line from the crest down to the trough. The teacher expresses how he likes this question because it does not simply ask the learners to write down the amplitude but rather to calculate the

		amplitude (LP; WDT; TS). He reveals that the learners will have to do some type of calculation. The teacher asks the learners for the answer and waits for them to answer (TS). A learner gives the correct answer. The teacher asks what it is she did to get the answer (LP; TS). She states that she divided by two. He says that he can see that the learners are confused about this question, but the learners disagree and indicate that they understand. The teacher still reiterates that the information given is from the bottom of the trough to the top of  2.5 Calculate the amplitude of the wave. (2) 2.6 Show that the period of the wave is 0.67 s. (2) 2.7 Calculate the frequency of the waves. (2) 2.8 Calculate the speed of the waves. (3) [18] the crest. Amplitude is only measured from the rest position up to a crest or down to the trough and so they have to divide the value given by two.
3	14:34-20:50	The teacher moves onto the next question which says "Show that the period of the wave is 0.67 s". The teacher tells the learners to think first and to see what it is they have been given (TS). He revises the two equations that they know, that is used to work out period and writes them on the board as being: *1/f and* time divided by the number of waves (CS; LP; TS). He allows the learners to discuss this question and to come up with the answer (TS). He poses the question: what do you have? And tells the learners not to rush (LP; TS). He asked the learners if they have information about frequency and they agree that they do not have the value for frequency. He then asks: what do you have? The learners indicate that they have information about the time and the number of waves. He does the calculation on the board (TS). Learners are heard to be quite rowdy, but the teacher tells him to keep quiet and to give other learners the opportunity to speak and answer the questions. He reiterates where he got the values from in order to use the calculation and then moves on to the next question (Question

		2.7, see below) and allows the learners to get the answer themselves (TS). He probes the learners by asking if they have information about the wavelength or speed (TS). The learners indicate that they have the value for the period of the wave. On the board he writes the relevant equation for frequency: $f = 1/T$ and they substitute in the values as a class (TS). A learner points out that they could have used the other formula for frequency which is the number of waves divided by time. The teacher agrees and they do the calculation together to prove that they get the same answer (TS). The teacher moves on to the final question (Question 2.8, see below) and  2.6 Show that the period of the wave is 0.67 s. (2) 2.7 Calculate the frequency of the waves. (2) 2.8 Calculate the speed of the waves. (3) [18] writes the equation on the board of $v = f \times \lambda$ (TS). They discuss it and place the relevant values into the equation in order to get the answer. The teacher hears a learner say the term *minutes*. He pauses and points out to them that it is not minutes and that it will be...he pauses... and allows the learner to answer (TS). The learner answers by saying "it will be *metres*".
4	20:50 – 35:19 And 00:00 – 00:40 of video two.	The teacher puts another set of questions up on the whiteboard using the projector and states that they have 10 minutes to complete the questions (TS) – see the questions below. The teacher reads through the question information with the learners (TS). The question is based on a ripple tank. He points out that they now have a ripple tank and so he will be using it to demonstrate to the learners how it works. The question information states that the distance between 13 consecutive wave crests in a ripple tank is 1,80m and that the wave travels through the water at a speed of 0,225 m/s. The teacher asks the learners if he can give them a clue for question 2.2.1, which is to calculate the wavelength of the wave, in meters and that it is to draw the 13 consecutive wave crests in order to determine the number of waves (TS). He explained this because the question does not state

		13 consecutive waves, it states 13 consecutive wave crests. The teacher makes the learners aware of the fact that they may make this mistake and write down 13 as the answer to the number of waves (LP; WDT). He tells the learners how to work out the wavelength of the wave by taking the distance given as 1.8 m and dividing it by the number of waves. He then allows the learners to continue answering the questions on their own. The teacher points out that they could not have used the formula $v = f \times \lambda$ to determine the wavelength. The teacher reiterates that to work out the wavelength, they will have to take the total distance given and divide it by the number of waves (TS). He asks the learners how many waves they see to be present after drawing the 13 consecutive waves (TS). The learners indicate that there are 12 waves. He stipulates that through a simple division they get the answer to Question 2.2.1. He allows the learners to continue with the rest of the questions. The teacher discusses that the reason for today's lesson is to carry out calculations on the concepts of wavelength, frequency, period and speed (TS). The teacher is seen to walk around the classroom while indicating how much time they have left to answer the questions (TS). The teacher moves the questions down the screen (by scrolling down on his laptop) so that further questions are available for the learners to answer. A little while later the teacher scrolls down even further so that the last two questions regarding amplitude can be seen. He indicates to the learners that information about *time* has been given, giving this information as a hint. The participant goes over the definition of Period again describing that it is the time taken for one cycle (LP). He asks the learners if they remember what the definition of 'period' is while he walks around the class watching the learners do the calculations (CS; TS). He is heard helping learners.

		 2.1 The distance between 13 consecutive wave crests in a ripple tank is 1,8 m. The waves travel through the water at a speed of 0,225 $m \cdot s^{-1}$. 2.1.1 Define the term *wavelength* of a wave. 2.2 Calculate the ... 2.2.1 wavelength of the wave, in meters. 2.2.2 frequency of the wave. 2.3 The graph below shows the displacement of a leaf on a dam at intervals of 0,2 s after a disturbance has moved through the water 2 $m \cdot s^{-1}$. 2.3.1 At position C, is the leaf moving upwards or downwards? (1) 2.3.2 Consider the points A,B, C and D in the diagram. Identify TWO points which are in phase. (1) 2.4 Calculate ... 2.4.1 the frequency of the wave. (2) 2.4.2 wavelength produced. (3) 2.5 What is meant by the term amplitude of a wave? (2) 2.6 The amplitude of the wave is now doubled. What is the value, in metres, of the new amplitude of the wave? (2) [19]
5	00:41-5:09 video two of lesson 1	The participant is heard saying that a two-step calculation will be acceptable (with Question 2.4.2). The teacher scrolls down further so that the last two questions regarding amplitude can be seen. He then reads out question 2.6 (TS). He reveals to the learners that they first need to identify what the amplitude is before it is doubled

		and that it will be determined from the graph (TS). He is trying help them answer the question. He points out to the learners that they are going to give many different answers to the question because when it comes to amplitude, they (the learners) do not know where to start (LP; WDT; TS). He tells the learners to look at the diagram (RP) and to determine the amplitude before doubling it. He indicates that he can see that learners are getting frustrated about the question because it is asking about amplitude (LP; WDT; TS). The bell rings. He signifies that Question 2.6 is asking for the value in metres whereas on the graph it is given as centimetres (LP; WDT). He tells the learners that they have one more minute to finish up. He makes the learners aware that up to this point they have been focusing on transverse waves and so moving forward they will be looking at the next type of wave which is the longitudinal wave (CS). He reveals that they are still going to do more calculations as he can see that learners are struggling with them. He states that in tomorrow's lesson, they will be discussing longitudinal waves and will do further calculations in their allocated intervention and remedial time periods. The teacher tells the learners that once they get home they need to go through longitudinal waves because in the lesson tomorrow they're going to discuss how these waves are propagated, how to determine the wavelength and how to do the calculations but with longitudinal waves (CS). He asks the learners to hand in their books.
6	00:00 -2:51	Start of lesson 2: The teacher had the word *Longitudinal Waves* written on the board. The teacher reminds the learners that yesterday, in the lesson they covered the basic principles and aspects about how a longitudinal wave is different to a transverse wave (I was not present for this lesson). The participant asks the learners how the propagation of longitudinal waves is different to transverse waves (CS; TS). He allows the learners to answer but nobody answers and he reminds the learners that they briefly discussed this yesterday (LP; TS). He re-asks the question: distinguish between the propagation of a transverse and longitudinal wave (TS). A learner

		answers by saying that the disturbance of the medium in a longitudinal wave is parallel to the direction of the wave. The teacher asks parallel to what? (TS) and the learner response, "to the direction of the wave". The participant points out that in a transverse wave there is a crest and a trough and then he asks the learners what they recognise to be different in the longitudinal wave and what is seen to be new on the longitudinal wave (LP; TS). He asks the learners what they see, by referring to a diagram in their textbook (RP). The learners are now aware of only answering individually and a learner answers that it comprises of compressions and rarefactions. The teacher asks the learners what is meant by compressions (CS; TS) and a learner answers that the coils are closer together. The teacher affirms that yes, it is true but only if it is illustrated on a spring (TS). He then asks what rarefactions are and in chorus the learners answer that it is when they are further apart (CS). The teacher indicates that there are two volunteers who want to come forward. They will emphasize the properties of longitudinal waves so that as a class they can see the key points. They will also cover the questions relating to the longitudinal waves that they got for homework the night before from the textbook (TS). The learners who have put together a poster on the topic of longitudinal waves come forward.
7	2:52 – 12:55	The learners introduce themselves. The one learner is holding the poster and the other learner has her book open and is about to start writing on the board. They begin with Question 2.2, Activity 1, page 25 of their textbook. The first question asks the learners to use their knowledge about a transverse wave and a longitudinal wave and to identify the numbered part of the waves shown in the figure below. The learner asks the class what number 1 represents and tells the learners to put up their hand to answer. She allows the other learners to give the answer. A learner answers with the incorrect answer. A learner in front corrects him and says that it is the crest. She explains why it is the crest and that it's because it is the highest point of the wave. She asks what part 2 represents, leaving the class to answer. They answer correctly stating that it is the ‘wavelength’. As a chorus

		number three is answered as the ‘amplitude’ and number four is answered as the ‘trough’. The two learners in front explain that it's because it is the lowest part of the wave. She asks what number 5 is and the class answer as a chorus that it is the rarefaction, with number 6 being the compressions. The learners move onto Question 3.1. A learner reads out the question which states: George moves the free end of a spring which is shown by sketch; one repeatedly forwards and backwards to create a wave to the right of the spring; which is shown in sketch; name the areas X and Y in sketch two. The teacher indicates to the learners that they need to put up their hands (TS). A learner answers that X is a compression and that Y is the Rarefaction. The learner standing in front of the class asks the rest of the learners in the class what a ‘rarefaction’ is. A learner answers correctly. They move onto Question 3.2 which asks what type of wave is seen to move through the spring. A learner answers correctly and that it is a longitudinal wave. The learner in front indicate that it's a longitudinal wave because the propagation is parallel to the direction of the wave. They move on to the next question which asks what a longitudinal wave is. A learner answers reading from her textbook. The teacher then asks the learners if they understand the definition considering that they've just read it from the book. The two learners standing in front reiterate the question asking the learners if they understand the definition. Some learners indicate that they do not understand and so the learners standing in front use their poster to explain the propagation of longitudinal waves as compared to a transverse wave. The learners still don't understand and so they re-word the definition. The other learner takes the opportunity to explain. The teacher prompts the two learners in the front to use a plastic bottle and water as an illustration (LP; WDT; TS). The teacher steps in and explains that with a transverse wave the propagation of particles is upwards whereas the propagation for transverse waves is parallel to the direction it's moving in, meaning that it is in the same direction as the movement of the wave (CS). The learners in the front ask if they understand and eventually they all indicate that they understand.

		They move onto question 3.4. The question states that during this wave motion the compression to compression distance is 10 m and takes 5 seconds to move past the same point. Question 3.4.1 asks what the wavelength of the wave is. The learners in the front asks the class if they know the answer. No one answers. The learner in the front asks the learners to listen to the question and to refer to both transverse and longitudinal waves. They indicate that if they understand the question and know the definitions of both waves; then they will understand how to get to the answer, because it does not involve any calculations. The learner answers, and the teacher adds to the conversation to tell the learner to explain why. The learners in the front hold up the poster and explain that with a transverse wave the wavelength is from two successive points either from crest to crest or trough to trough. With a longitudinal wave the wavelength is from the centre of a compression or rarefaction point to the next centre point of a compression or rarefaction. They confirm that the answer to lambda is 10 m. The next question asks what the speed of the wave is. The learner in the front asks the learners before answering the question to define speed. A learner answers that speed is velocity. The teacher points out that they are not doing mechanics (LP; TS). The teacher explains that speed is to do with distance over time and the answer is done on the board which is calculated to be 2m/s and the teacher ensures that the learners understand that it is in metres per second.

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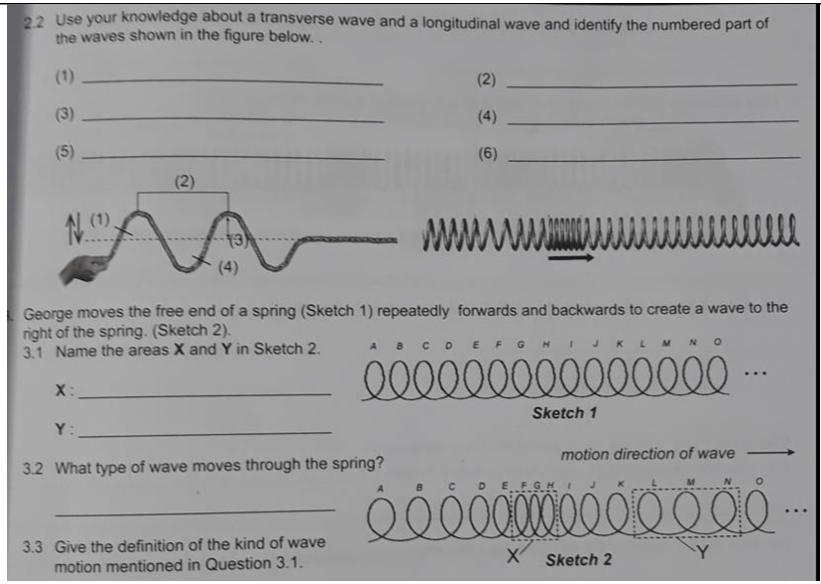

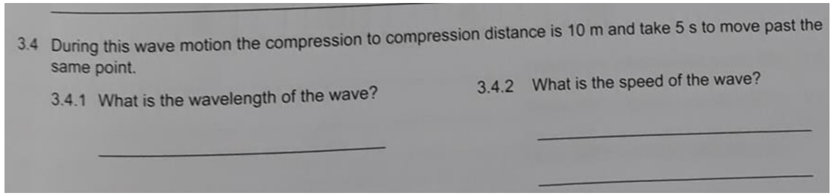

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<tr><td>8</td><td>12:56 – 17:15</td><td>The learners in the front move on to Question 4 (see below) and allow a learner in class to read out the question. The question states that a longitudinal wave moves along a slinky spring, at the moment shown below, positions A and B are the centres of a compression and a rarefaction respectively and are 24 cm apart. Question 4.1 asks what the wavelength of the wave is. One of the learners in the front of the class writes down the equation, $v = f x \lambda$ on the board and points out that they don't have the frequency or the wavelength and therefore they have to use the equation of wavelength equal to the length of the wave over the number of the waves. She explains that the wavelength of a longitudinal wave is from the centre of a compression to the centre of the</td></tr>
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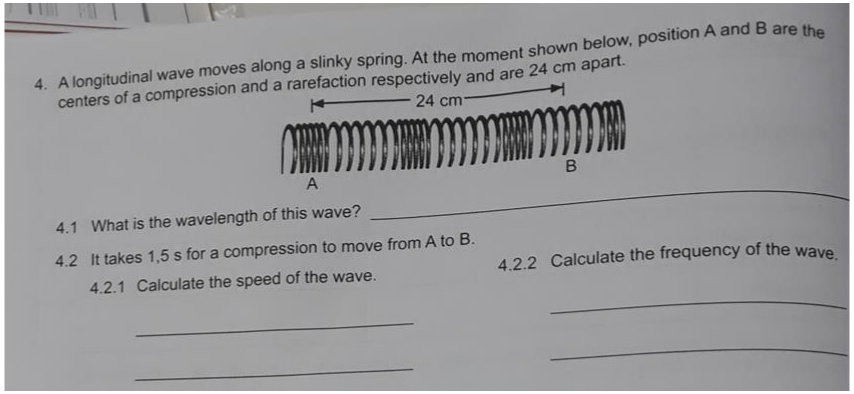
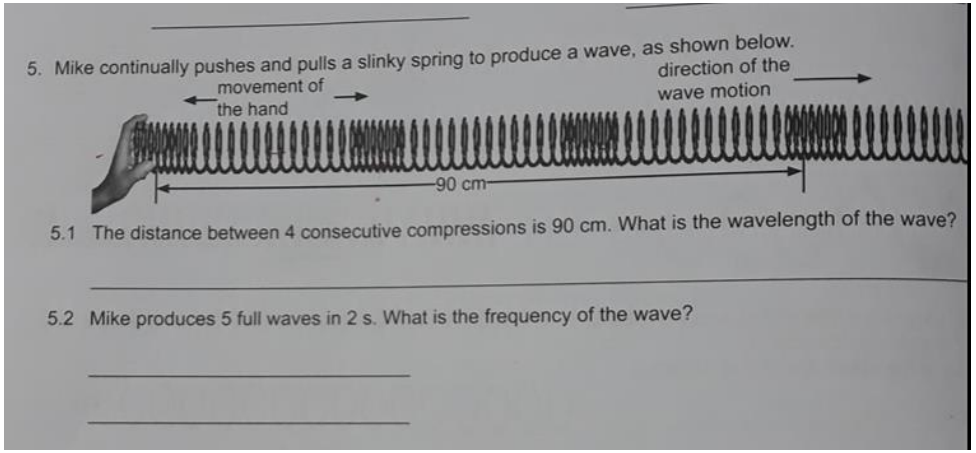
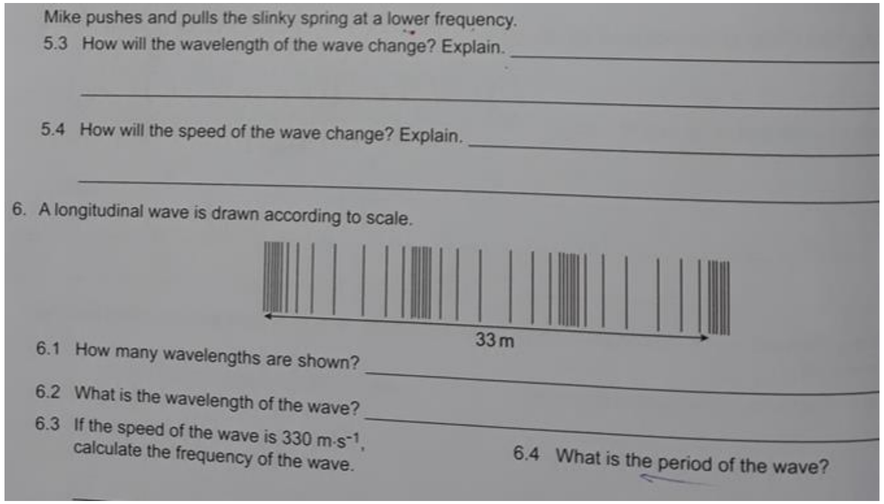
next compression. She counts how many waves are present in the image given and indicates that there are two and a half waves. She shows the learners on the board and substitutes the length of the wave, which is 0.24 metres and divides it by 2.5, giving the answer of 0,096m. The teacher asks if the learners understand and he reiterates that they converted the centimetre value into metres and indicated that learners may be confused as to how the class got 2,5 waves (LP; WDT, TS). The learners use the poster to reiterate how to work out the wavelength of a longitudinal wave. The teacher tells the learners to look at the image in the book (RP) and to use their fingers together to determine how many waves there are in the image given (TS). Eventually the learners understand. The next question is read out which is Question 4.2. It states that it takes 1.5 seconds for a compression to move from A to B and that they are required to calculate the speed of the wave. The learners in the front of the class asks the class how they calculate the speed of the wave and leave the rest of the learners to answer. They write on the board that they will use the equation distance over time. They substitute the given values to get the answer after which the teacher reiterates what they have just done using the values in the equation.



9	17:16 -21:11	At this point the teacher reveals that he doesn't believe learners have difficulties with this equation but rather have difficulties in reading off the diagram (RP; LP; WDT). The learners in the front ask a learner to read the next question which is to calculate the frequency of the wave. The learners in the front indicate that there are many ways to work out the frequency of a wave and indicate that they do not have λ or v and thus they will use $f = \frac{1}{T}$ and show the substitution values of 1 divided by 1,5 giving an answer of 0,67 Hz. The teacher is heard asking the learners in the front again why they do not use equation v = f x λ and the learners indicate that they do not have a value for λ or v (TS). At this point the learners recognise that they have in fact got a value for v and can use the equation to calculate frequency using the equation rearranged as $f = \frac{v}{\lambda}$. With velocity being 0,16 and lambda being 0,096, the learners calculate frequency to be 0, 67 Hz. The teacher corrects the learners by making them aware that the period is not 1.5 seconds as 1.5 seconds does not explain the time taken for one cycle but rather 2.5 cycles (WDT; TS). The learners in front ask another learner to read out Question 5. The question states that Mike continually pushes and pulls a slinky spring to produce a wave as shown below. The teacher interrupts the learners at this point and goes back to the previous question regarding $f = \frac{v}{\lambda}$ in order to add further knowledge (TS; WDT; LP). He teacher makes the learners aware that frequency can also be calculated using $f = \frac{number\ of\ waves}{time}$ and therefore they could have used the equation substituting the values of 2.5 divided by 1.5 to get 1.67 Hz.
10	21:12 – 27.18	The learners now continue with Question 5 and 5.1 and so the same learner as before reads the question from the beginning: Mike continually pushes and pulls a slinky spring to produce a wave as shown below. The distance between four consecutive compressions is 90 cm, what is the wavelength of the wave? The teacher

		declares that it is a good question (CS). The learners in the front ask the rest of the learners to reiterate how to determine the wavelength on a longitudinal wave. They answer that it is the distance between two centres of successive compressions or rarefactions. The learners in the front then further ask the learners to compare how to determine the wavelength of a transverse wave when compared to a longitudinal wave and also asks if they are different and if so, how they are different. She allows the learners to answer. Another learner answers that for a transverse wave the wavelength is measured from crest to crest and for longitudinal waves it is from the starting point... at this point the two learners in front correct him, filling in that it is from the centre, the same learner continues with other learners helping him indicating that it is from the centre of 1 compression to the next compression. They indicate that it can be the same but by using the rarefactions. While the one learner in the front is discussing the above, the other is seen writing $\lambda = \frac{length\ of\ the\ wave}{the\ number\ of\ waves}$ on the board. The other learner in front indicates that the question (Question 5.1) states that the distance between 4 consecutive compressions is 90cm and that it is there to throw the learners off because if they count how many waves there are; there are actually three in the space of 90 centimetres. The learners hold up the textbook to show the rest of the learners how they got three waves. They then substitute 90 centimetres as 0.9 m into the equation and divide it by 3 to get the answer of 0.3m. Some learners indicate that they are confused as to how they got three waves. The learners in the front hold up the textbook and reiterate how they counted 3 waves and that it is from the centre of 1 compression to the centre of the next compression. The learners then indicate that they understand. The teacher reiterates that in the space of 90 centimetres there are four consecutive compressions but it does not mean that it represents the number of waves (LP; WDT; TS). They move on to the next question (Question 5.2) and a learner reads it out aloud. The learner reads that Mike

		produces 5 full waves in 2 seconds stating that the question then asks what the frequency of the wave is. The learner on the board points out that they do not have λ or v so they need to use $f = \frac{number\ of\ waves}{time}$. A learner was talking and so the learner in front of the class asks that particular learner why it is that they are using that particular equation. That particular learner is unable to answer and another learner answers that it's because they do not have velocity and wavelength. They substitute the value of 5 over 2 to get to the answer of 2.5Hz. 
11	27:19 – 33:26	The teacher takes over the lesson and thanks the learners for all that they have done. The teacher now tells the learners that they need to look at Questions 5.3 through to Question 6 which relates frequency to wavelength and frequency, speed and wavelength and to then do the calculations. Before doing these calculations, the teacher reveals that there is one last question he wants to ask. The teacher asks if the learners know of any examples of longitudinal waves (CS; TS). He points out that they have spoken about how water waves are examples of transverse waves (LP). Now looking at longitudinal waves with the spring being the medium, what type of examples represent longitudinal waves? He continues to add, "where the disturbance and the

		propagation of the wave are parallel". He allows the learners to answer (TS). A learner shouts out the word *sound*. The teacher reiterates that it is sound waves. He specifies that sound waves need a medium to travel and that the next topic that they are going to cover, and tells the learners to go to page 28, is sound (CS). He tells the learners that they are going to look at sound waves as an example of longitudinal waves from the next lesson. He tells the learners to continue with the Questions 5.3 through question 6 and gives them the rest of the lesson to complete them. He then asks the learners if there are any volunteers that would like to introduce the topic of sounds waves like the learners did in this last lesson regarding longitudinal waves. A learner asks if she has to do it now and the teacher indicates that no, she may prepare it for the next day. The same learner then asks if she has to prepare a poster and the teacher answers by saying that she does not have to. The teacher reads out the question information about how Mike pushes and pulls the slinky spring at a lower frequency and tells the learners that they need to understand the relationship between frequency and wavelength to answer the question (LP; TS). The bell rings.  Mike pushes and pulls the slinky spring at a lower frequency. 5.3 How will the wavelength of the wave change? Explain. 5.4 How will the speed of the wave change? Explain. 6. A longitudinal wave is drawn according to scale. 33 m 6.1 How many wavelengths are shown? 6.2 What is the wavelength of the wave? 6.3 If the speed of the wave is 330 $m \cdot s^{-1}$, calculate the frequency of the wave. 6.4 What is the period of the wave?

12	00:00 -06:00	Start of Lesson 3: The teacher reveals they will be discussing sound waves and has his textbook in front of him. He states that as a class they need to discuss longitudinal waves and how they propagate and what it is that distinguishes them, from transverse waves (CS; TS). He reminded the learners that with longitudinal waves, one talks about compressions and rarefactions and with transverse waves; one talks about crests and troughs (LP). The teacher writes the term *sound waves* on the board and says to the learners that they now need to link longitudinal waves to sound waves, because sound waves is an example of a longitudinal wave (CS). The teacher asks in one sentence how sound waves originate and how they can be transmitted and if they will need a medium or if they will be transmitted in a vacuum (TS). The teacher writes on the board that sound waves are an example of longitudinal waves, indicating that it is the first key point (CS). He asks the learners how sound waves are produced and how one gets sound (CS; TS). A learner answers that it is through movement. The teacher probes further and asks: "through the movement of what?" (TS). He leaves the question unanswered for the learners to answer, but no one answers. He then used a real-life example of hitting a ruler or two blocks together to get a sound and asks, what happens when both are done? He further adds "or if it's a guitar? Why is there sound?" (LP; TS). The learners do not answer correctly and so the teacher writes on the board that sound is produced through vibrations (CS; TS). The teacher points out that the key word in that sentence is the word *vibrations*. He states that the learners now need to find out how sound is transmitted (CS). He asks the learners whether longitudinal waves such as sound need a medium to travel, or if they travel through a vacuum (TS). The teacher reiterates the meaning of a medium by indicating that the medium is a solid liquid or gas (LP; TS). The learners answer in chorus that sound waves do not move through a vacuum. The teacher then questions "so what you are saying is that sound waves need a medium?" (TS). He then writes on the board that sound waves need a medium to be transmitted. The teacher explains that it means that particles need to be

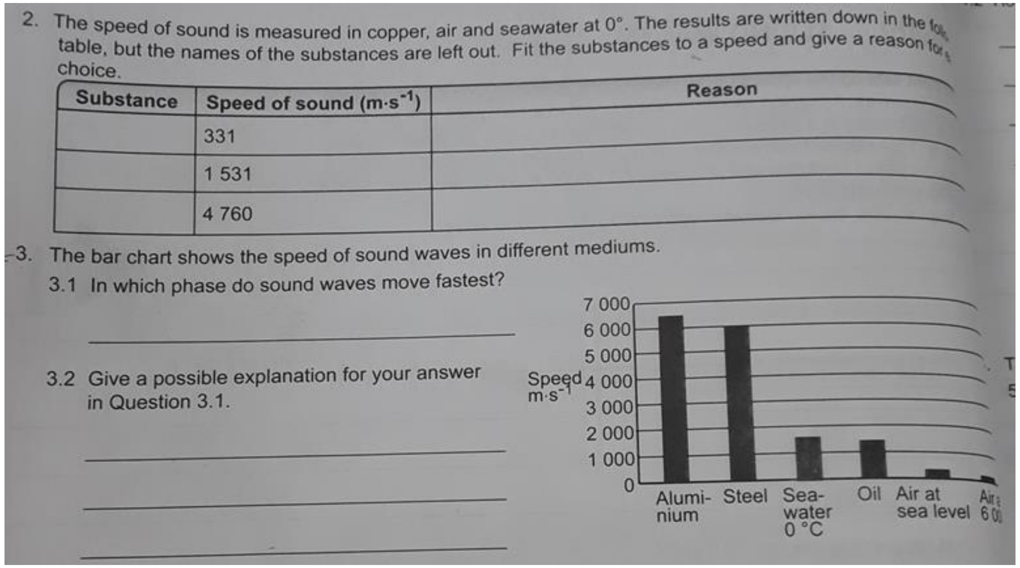
		colliding to allow sound to travel and indicates that without a solid, liquid or gas, sound cannot be transmitted and then write this down on the board (TS). The teacher then writes on the board, as the next point, that sound cannot travel through a vacuum. A learner asks the teacher what he means by a vacuum. The teacher asks if there is another learner that would like to answer that question before he does himself (LP;TS). No one offers and so the teacher tells the learners that a vacuum is like a vacuum flask, it has no particles and which means that there is no solid, liquid or gas present in the vacuum to transmit the sound (LP). He explains further about a vacuum flask, indicating that it would either keep whatever is in it, hot or cold (LP;TS).
13	6:00 – 15:12	The teacher moves on to discuss how sound moves in a solid, liquid or gas (CS). He asked the learners in which medium they think sound travels the fastest and asks a particular learner to answer (LP;TS). He restates the question and asks the learner to elaborate why (TS). The learner responds that it is in solids that sound travels the quickest. The teacher further probes and asks why (TS). He notices that the learner is explaining the reason nicely and asks the learner to come to the front of the class (TS). It is the same learner that asked in yesterday's lesson whether she had to develop a poster about sound waves if she was going to introduce the concept. The learner stands in front of the class and states that sound moves faster in solids compared to liquids and gases because solids are denser than liquids and gases and that in solids the particles are closer together. The teacher further adds that because the particles are closer together, they collide more often. He describes that in gases the particles are far apart. The teacher uses a real-life example: when someone is standing far away, he has to shout for them to hear him (LP; TS). He uses another example of the tin can phones. The teacher makes the learners aware that the textbook describes the tin phone and that the sound travels nicely because the string is a solid. He further explains that the sound will move better when the string is tight compared to when it is coiled. The teacher writes on the board, as the next point, that sound travels faster in solids because the particles

		are closer together and is denser than liquids and gases (CS; TS). The teacher reveals to the learners that they are going to discuss, while looking at the textbook, what is written on page 30. This states that sounds moves through air with a speed of 340 m/s and water at 1500m/s and steel at 5900m/s. The teacher makes the learners write down in their books that by using the information provided in the textbook, these values illustrate that sound moves faster in solids compared to liquids and gases (TS). He further adds that it is because the particles can bump and push into each other better in solids allowing sound to be transmitted. The teacher writes on the board that sound is a pressure wave and in brackets writes that particles press against each other (TS). He tells the learners to go to page 28. While waiting for the learners he states that on the page it shows and points out different sound sources. Through them, they can see how sound is produced. He further reiterates that sound is produced through vibrations. He makes the learners aware what he has written on the board, in the interim, about how sound is a pressure wave because particles press against one another, knowing that particles are required to allow sound to be transmitted (CS; TS). The teacher reiterates that if there are no particles, sound cannot move because there will not be anything that can pump and push against each other (LP). He then tells the learners that they are going to look at the example on page 28. He asks the learners what they see in the textbook and asks a particular learner to answer (TS). The learner answers that it is an instrument. The teacher reveals that it is a tuning fork and that if one hits it, one gets sound. He explains that by hitting it, vibrations occur, causing the particles to have compressions and rarefactions, allowing sound to be produced. The teacher moves onto the next real-life examples in the textbook that explain scenarios that prove that sound is produced through vibrations. The teacher asks the learners what they are being shown in the question. He asks a learner to read the first scenario (TS). The learner reads the scenario which proves that sound is produced through vibrations shown by a piece of paper moving on a piece of wire. They move on to the next scenario. The

		scenario illustrates that when polystyrene balls are placed onto a drum by using the drumsticks to hit the drum skin, the polystyrene balls move up and down on the drum due to the vibrations. The teacher points out that the word 'vibration' is the key word in that statement. They move onto the next scenario that explains that by connecting a loudspeaker to a signal generator and placing small polystyrene balls onto a loudspeaker, Figure 5 in the textbook, vibrations of the speaker cause the polystyrene balls to move. The teacher reiterates that the key phrase is that 'sound is being produced through vibrations. The teacher tells the learners to look at the figure with the speaker and reads from the textbook that when sound moves outward, compression and rarefactions are formed, which is a characteristic of longitudinal waves. When there is a series of them, one gets a wave causing sound to be produced. He tells the learners to go to number 2 on page 88.
14	15:13 – 30-29 of video 1 + 00:00 – 04:33 of video 2.	The teacher tells the learners to do the questions on page 88 from question 2 and to not write down the questions in their books, only the answers (see the questions below). The teacher asked a learner to read out the question which states that the speed of sound is measured in copper, and seawater at 0°. The results are written down in the following table, but the names of the substances are left out. The teacher tells the learners to fit the substances to the corresponding speeds and to give a reason for their choice (TS). The teacher then discusses the question with the learners and asks them which substance has the speed of 331m/s (TS). In chorus the learners answer that it is air. The teacher asks the learners to give their reason (TS). A learner answers that the reason is because the gas is less dense causing the speed in gases to be the slowest. The teacher further adds that the particles are far apart. The teacher asks them which substance has the speed of 1531m/s (TS). The learners answer that it is sea water. The teacher adds to the answer saying that the seawater is a liquid and that the particles are further apart when compared to a solid. The teacher moves on to say that the last one will be copper because it is a solid and that the particles are closer together, are denser, and so the particles can easily bump and push causing sound to be propagated. The teacher moves on to Question 3 and states that the 'bar chart' shows the speed of sound waves in different mediums. The teacher reads out the different mediums seen on the bar chart which are

		aluminium, steel, seawater, oil, air at sea level and air at 6000m. The teacher reads out question 3.1 which asks: in which phase do sound waves move the fastest? He allows the learners to answer (TS). He makes the learners aware that aluminium and steel are the solids, sea water and oil are the liquids and the air at sea level and at 6000m are the gas (LP). He then answers the question by saying that it is the solid phase, because the particles are denser compared to the liquid and gases. He moves on to Question 3.3 allowing a learner to read it out. The question asks what effect an increase in the temperature of seawater would have on the speed of sound waves and to explain the reason. The teacher tells the learners to go to page 30 because it states on that page that the higher the temperature the higher the speed of sound (TS). He also makes the learners aware that they spoke about this effect in grade 9 by discussing what factors affected resistance, with one of them being temperature (CS; LP). The teacher explains that with an increase in temperature the particles will gain more kinetic energy so the particles can easily move and easily knock into each other, so sound is transmitted easily. The teacher repeats question 3.3. The teacher gives the learners a minute to answer the question. He then states that the answer is going to be, *to increase*. The teacher reiterates that when one heats water, the particles gain kinetic energy and that they expand, being closer together, to transmit sound easier (CS). He also reminds learners that sound needs the presence of particles (LP). He further adds that often learners find themselves shouting so that the person can hear them because air particles are far apart and take time to bump into each other to transmit the sound. The teacher moves on to Question 3.4 which asks what connection exists between the speed of sound in air at sea level and air at 6000 m and to explain. The teacher tells the learners to look at the graph in the textbook. That teacher states that at sea level the speed is higher than through air at 6000m and asks the learners why (TS). The teacher first tells the learners that they need to look at the relationship. He again makes the learners aware that they spoke about this in grade 9, about the atmosphere (CS; LP; TS). He asks the learners what is happening as one goes up (TS). He asks if speed decreases or increases (TS). The learners indicate that it decreases. He tells the learners the answer stating: that the speed of sound decreases as height above sea level increases (TS). The teacher then asks the learners, "why" (TS). He asks a specific learner to answer. The learner answers by saying, "the air at sea level is much denser than the air as you go up". The

teacher further adds that the higher one goes the more temperature decreases and becomes cooler. He reminds the learners that as altitude increases the temperature decreases and becomes cooler (LP). The teacher explains that it means that particles are far apart and do not have a lot of kinetic energy and do not easily transmit sound. He tells the learners to look at Questions 4 and 5. He indicates that from there, in the lesson tomorrow they will be covering pitch, amplitude and loudness. He gives the learners five minutes to answer the two questions.



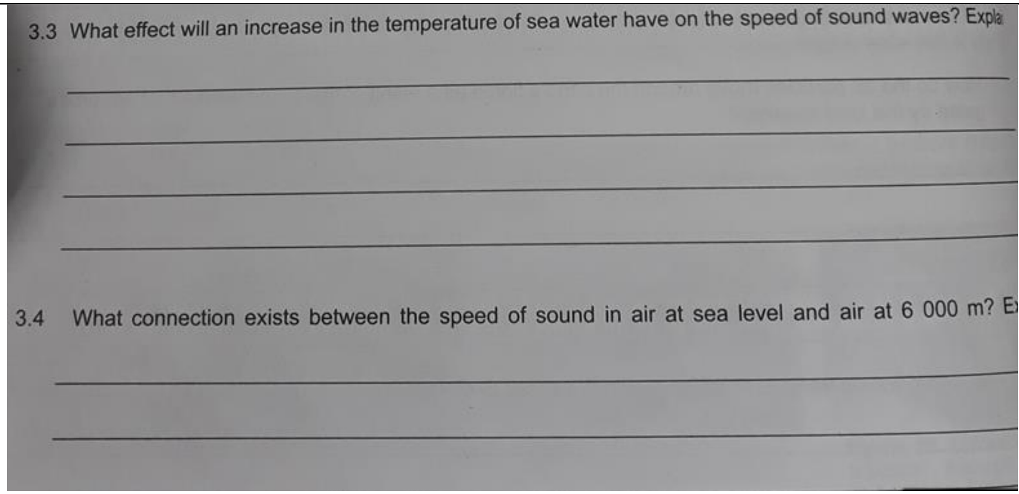
2. The speed of sound is measured in copper, air and seawater at 0°. The results are written down in the fol[...] table, but the names of the substances are left out. Fit the substances to a speed and give a reason for [...] choice.

Substance	Speed of sound ($m \cdot s^{-1}$)	Reason
	331	
	1 531	
	4 760	

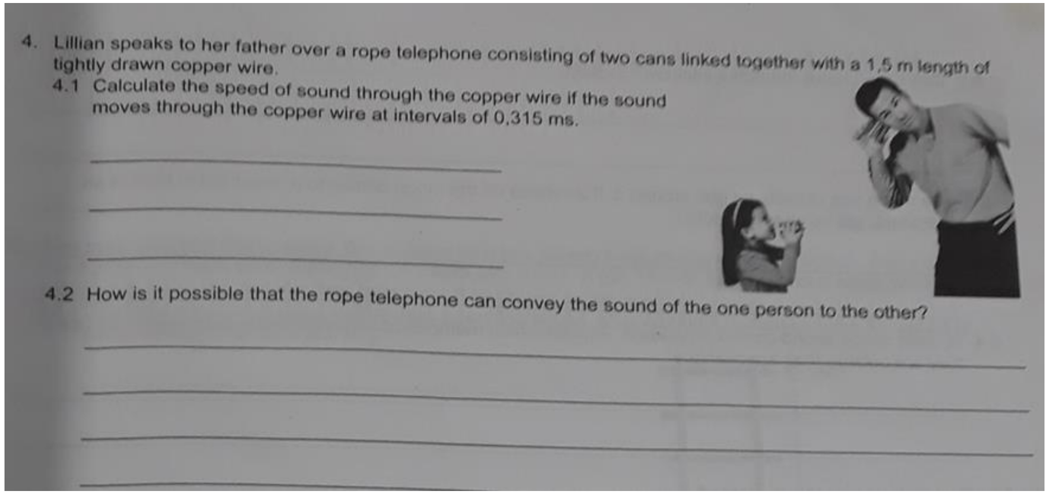
3. The bar chart shows the speed of sound waves in different mediums.

3.1 In which phase do sound waves move fastest?

3.2 Give a possible explanation for your answer in Question 3.1.

		 3.3 What effect will an increase in the temperature of sea water have on the speed of sound waves? Expla 3.4 What connection exists between the speed of sound in air at sea level and air at 6 000 m? E The teacher reveals to the learners that there are calculations in the questions given and reminds the learners that speed equals distance divided by time and that in the question they have a value for distance and time (CS; LP; TS). The teacher points out that Question 4.1 is straight forward but is worried about Question 4.2 (LP; TS). The teacher asks the learners how it is possible that the rope telephone can convey the sound from the one person to the other (TS). A learner comments that they have never used a rope telephone. The teacher responds by saying that these days the learners have phones but back in the day he would play with the rope telephones all the time. The teacher asks the learners if they are finished with Question 4.2. A learner answers that they are and so the teacher moves on to Question 5 indicating that they are now moving onto information relevant to Athletics Day (LP). The teacher asks the learners who was at Athletics Day and makes them aware of the fact that on the day there was a starter and there were timekeepers. He asked the learners what they thought about when the timekeepers would start the stopwatch (LP; TS). A learner indicated that it is when they started running. The teacher asked the learners whether the timekeepers are told to start the stopwatch when they hear the sound of the gun or when they see the smoke from the gun (LP; TS). Some learners indicate that it should be before

the sound and when they see the smoke. The teacher asks the class why they should start the stopwatch when they see the smoke and not when they hear the sound (TS). A learner answers that it could possibly be because 'it' is delayed. The teacher agrees and explains that the sound takes time to travel from the gun to the timekeepers and moves slower than seeing the smoke (CS). The teacher also makes the learners aware that sometimes with a gun there is a flash which is seen before the sound is heard also indicating that light moves faster than sound (CS). The teacher reads out Question 5 which states that the timekeeper at 100m athletics track race presses his stopwatch when he hears the bang of the starter pistol. Question 5.1 says, explain why this is an inaccurate method and suggest a better hand method. The teacher states that it is inaccurate because there is a delay in hearing the sound compared to seeing the smoke. The teacher moves on to question 5.2 which asks the learners to calculate how many seconds his time reading deviates from the correct reading if the speed of sound taken is 343m/s. The teacher asks the learners, in a storm, do they hear the thunder or see the lightning first. The learners indicate that they see the lightning first. The teacher further comments that when they see the lightning, they know that the thunder is going to come. The bell rings and the teacher tells the learners to finish the Questions up to 5.3 so that they can hand them in tomorrow



4. Lillian speaks to her father over a rope telephone consisting of two cans linked together with a 1,5 m length of tightly drawn copper wire.

4.1 Calculate the speed of sound through the copper wire if the sound moves through the copper wire at intervals of 0,315 ms.

4.2 How is it possible that the rope telephone can convey the sound of the one person to the other?

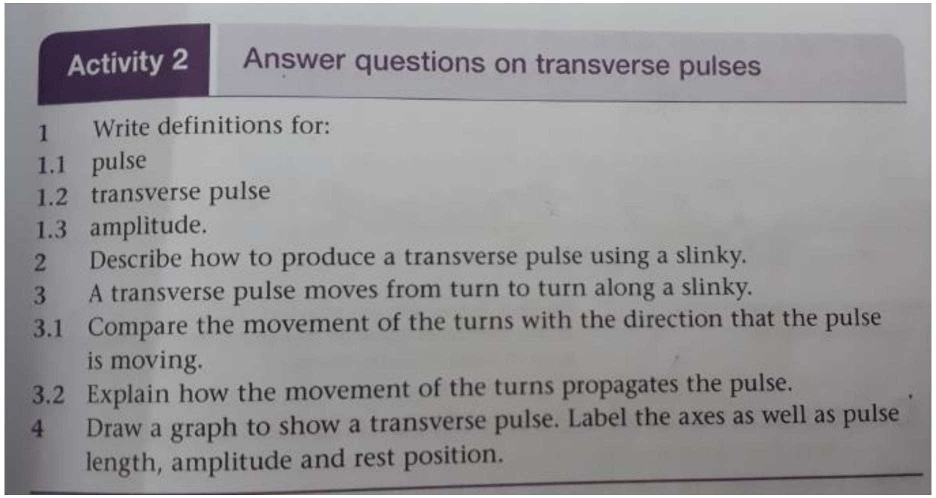
		5. The timekeeper at a 100 m athletics track race presses his stopwatch when he hears the bang of the starter pistol. 5.1 Explain why this is an inaccurate method and suggest a better hand method. __________ __________ __________ __________ 5.2 Calculate with how many seconds his time reading deviates from the correct reading if the speed of sound is taken as 343 $m \cdot s^{-1}$. __________ __________ __________ __________ 5.3 How does the speed of sound in air on a very hot day differ form the speed of sound on a very cold __________ __________ __________	

APPENDIX M: LESSON NARRATIVES FOR CRAIG

Sections	Time	Narrative and coding
1	00:00-14:10	The teacher has the textbook open on the desk in front of him. He indicates to the learners that they are going to start a new physics section today called ‘waves’. The teacher reveals that they are going to be discussing waves, sound and light and writes *waves*, *sound and light*, as a heading on the board. Under this topic he reveals that they are going to be dealing with transverse waves and draws a branch from the heading and writes it on the board, under which he then writes the word *pulse* and *waves* (CS). From the heading, he also draws a branch and writes *longitudinal waves* (CS). He draws another branch down from the heading and writes *electromagnetic spectrum* (CS). He indicates that what he wants to start doing, is writing down some definitions and terms, which the learners are going to meet from time to time (CS). The first is to define a *pulse* (CS). He asks the learners what a pulse is and allows the learners to answer. He then states that it is a single disturbance and writes it on the board (CS; TS). He adds that it is a single disturbance in a medium. He explains that if one has a medium and there is a disturbance, one is generating a pulse. He then asks the learners the definition of a medium (CS; TS). He leaves the question unanswered but the learners do not comprehend so he explains that it is a substance where a wave or pulse moves and writes it on the board (TS). He asks the learners to give him an example and a learner responds with the word, ‘water’. The teacher asks the class for further examples (LP; TS). Another learner gives the word, ‘air’. A learner is not clear on the instruction and so the teacher reiterates that he would like examples of a medium, in which a wave or pulse moves and asks for further examples. Another learner answers with the word ‘string’. A learner asks whether a tin can is a medium, the teacher writes this example on the board. The teacher reiterates that anything that allows a wave to move in it, is termed a *medium*. The teacher refers to the textbook and asks the learners for the definition of a *wave* (CS). No one answers so he states that it is a succession of pulses and writes the definition on the board. A learner asks the teacher what the word succession means. The teacher explains that when one

		is making a disturbance, a pulse is formed. Then, when one keeps making disturbances there will be more pulses so when there is a succession of these pulses, one is forming a wave. The teacher goes back to the textbook and asks the learners the next definition of the word *oscillations* (CS). He leaves the question for the moment but no learner responds (TS). He asks the question again and then answers it by stating that it is a 'vibration' (TS). The teacher then writes the word *frequency* (CS) on the board and asks the learners to give the definition (TS). A learner answers that it is the number of cycles of waves per second, which is the definition from the textbook. The teacher reiterates that it is the number of cycles, oscillations or wave per second and writes it on the board. The teacher then asks the learners what frequency is measured in and soon after writes down that it is in Hertz, also giving its symbol (TS). A learner is heard asking the teacher for the meaning of frequency and the teacher reiterates that it is the number of waves per second. The teacher points out that another term that needs to be understood is called *period*. He asks the learners what they believe to be a 'period' (TS). A learner responds by saying that it is the time taken for one complete wave cycle or oscillation, again believed to be read from the textbook. The teacher writes it on the board. The teacher explains that because *period* is time, it is measured in seconds (LP; TS).
2	14:11 - 16:51	The teacher moves onto the definition of *amplitude* (CS). He asks the learners what the term amplitude means and a learner is heard answering, that it is a measure of how big a pulse is. The teacher asks the learners again what the definition of amplitude is (TS). He writes on the board that it is the maximum disturbance of a particle from its rest position. The teacher starts to explain that particles before they move are on a rest position, and once disturbed, the distance from the rest position to where they end is called the amplitude. He implies that these terms will be what they are going to come across from time to time, during the section.
3	16:52- 22:46	The teacher writes down on the board the heading *transverse pulse* (CS) and indicates that they are going to talk about the transverse pulse. He reminds the learners that in this section, they are going to cover "two types", the first being the 'transverse wave' and the second being the 'longitudinal wave' (CS). He reveals to the learners that they are going to define the *transverse pulse*. The teacher states that with a transverse pulse, the particles will be moving at right angles to

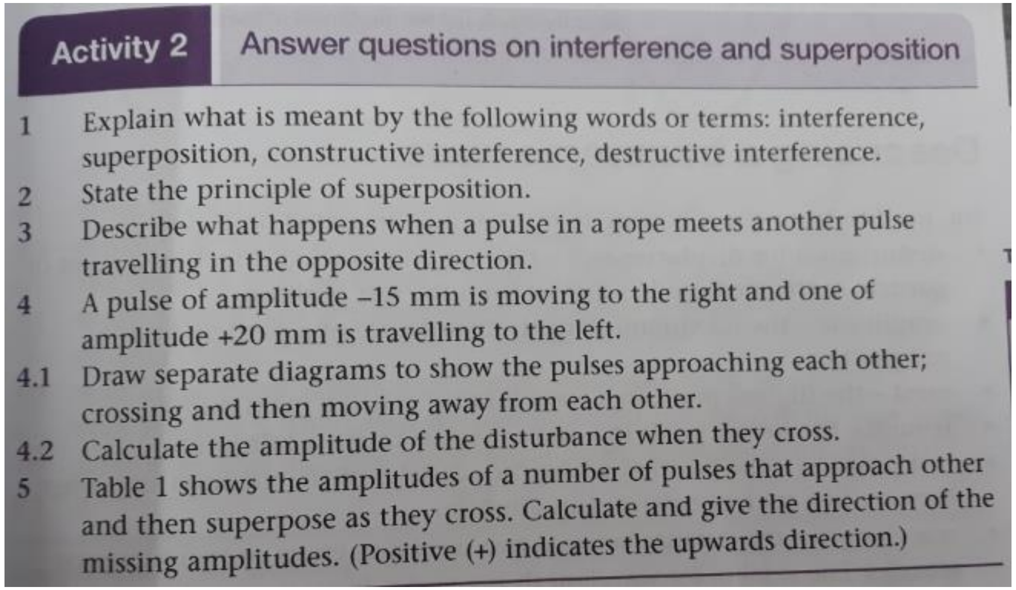
		the direction of propagation (CS). He repeats that the particles in the medium will be moving at right angles, or perpendicular to the direction of propagation. After looking at the textbook the teacher walks to the board and writes on the board the definition which he has just explained. He starts to draw a positive *x* and *y* axes with the x-axis representing the rest position. He then draws a disturbance (RP). He continues to draw a line from the rest position to the top of the disturbance and implies that it is the amplitude. (CS) He reiterates that it is between the rest position and where the particle goes. On the diagram he draws a line from where the pulse starts, to where the pulse ends. He explains that that is termed the p*ulse length* (CS). A learner asks the teacher if the pulse length is the same as the wavelength (WDT) which is a term they have not yet been introduced to. The teacher specifies that the pulse length and the wavelength are not the same. He teaches the class that a pulse length is where a single disturbance starts and ends (WDT; LP). He reiterates that a pulse is a single disturbance and that they will discuss wavelength at a later stage (CS). He states that pulse length and wavelength are therefore different. Wavelength will be discussed later. He asks the learners if there are any questions based on the definitions covered and if anyone needs clarification on the definitions (TS). A learner raises her hand and says that she needs clarification on the definition of oscillation. Another learner asks the teacher what he means by the term succession. The teacher asks the class what a succession is and he leaves the question unanswered (TS). A learner answers that it is the number of success. The teacher re-asks the question (TS). Another learner says, "is it not the achievement". The teacher is heard asking, as a joke, whether they need to go back to English class and then continues to leave the learners thinking about its meaning. After which the teacher asks the learners: "if things follow each other in succession, what does it mean?" soon after the teacher explains that it means one after another so, it is saying that if there is a succession of pulses, it means that there are pulses happening one after another. They are following each other (TS). The teacher thanks the learner for asking such a question. Another learner puts up her hand and also asks about the definition of oscillation and asks if it is the same as a wave cycle. The teacher points out that one can use the term wave cycle instead of the term oscillation (LP;TS). The teacher asks if there are any further questions. Another learner asks about the definition of amplitude and asks if it can't be defined as the 'length'. The teacher specifies that the right term

		is called the amplitude because one has to define what length it is, while indicating it on the diagram (RP). Another learner asks a question but the question is not heard clearly. The teacher goes to the textbook and tells the learners to go to page 79 and to do questions 1 and 4 from activity 2 in their class books (TS). The learners are given eight and a half minutes until the bell rings to do the questions.  **Activity 2** Answer questions on transverse pulses 1 Write definitions for: 1.1 pulse 1.2 transverse pulse 1.3 amplitude. 2 Describe how to produce a transverse pulse using a slinky. 3 A transverse pulse moves from turn to turn along a slinky. 3.1 Compare the movement of the turns with the direction that the pulse is moving. 3.2 Explain how the movement of the turns propagates the pulse. 4 Draw a graph to show a transverse pulse. Label the axes as well as pulse length, amplitude and rest position.
4	00:00 – 04: 27	Start of lesson 2: The teacher turns to the relevant page in the textbook before starting the lesson. The teacher reminds the learners, that for homework they had to do questions 1 and 4 of Activity 2 on page 70. He asks the learners what they wrote down for the definition of a pulse (TS). He asks what a pulse is and then soon after states that it is a single disturbance, and in chorus the class say…in a medium. He points out that the learners were supposed to also give the definition of a transverse pulse and asks the learners for its definition (TS). A learner responds by saying that it is a pulse in which the particles of the medium, move at right angles to the propagation of the wave. The teacher then indicates that the learners needed to give the definition of amplitude. The teacher asks: "what is the amplitude?" (TS). A particular learner answers that it is the maximum disturbance of particles from the rest position. The teacher then moves on to

		question 4. The teacher explains that the learners were to draw a graph to show a transverse pulse and that they had to label the axes as well as the pulse length, amplitude and rest position. The teacher draws the positive *x* and *y* axes and proceeds to draws a pulse (RP). Using arrows, he represents the pulse length, the amplitude and labels the *x*-axis as the rest position (RP). The teacher then reveals that he needs to move on to discuss the superposition of pulses (CS).
5	04:28-21:40	The teacher writes on the board the heading *superposition of pulses*. He reminds the learners that a pulse is a single disturbance. If one continues producing these pulses, in succession, it will then be termed a wave (CS; LP; TS). The teacher then explains that if two pulses meet at the same point at the same time, they will interfere with each other. He asks the learners "if the waves interfere; what does it mean?" (TS). A number of learners are heard answering at the same time. One learner says, "they will meet each other". The teacher re-words the question and says that if the waves are interfering with him, what does it mean (LP; TS). Another learner says that they are disturbing each other. The teacher explains that it can be a positive or negative interference and that if one mixes with people there can be a positive or negative interference (LP; TS). He implies that this effect is what also happens when pulses meet each other. The teacher expresses that the first thing they need to do is define 'interference' (CS). He allows the class to define it and then soon after states, while writing on the board, that interference is when two or more pulses meet or interact with each other at the same space and time (TS). He reminds the learners that the class discussed that interference can be positive and negative and this brings them to the principle of superposition (LP; CS). He tells the learners to write the following while reading from the textbook: "it is said that when pulses cross, their combined disturbance at any point, is equal to the sum of their disturbances". The teacher then explains that if two pulses meet at the same point, the effect is the sum of the disturbance (CS). The teacher asks the learners what is meant by the term *disturbance* (TS). The teacher then states soon after, that it is the amplitude, which means that when they meet in superposition, one is saying that when the pulses meet it will be the sum of their amplitudes (TS). He further adds that it is an addition of the amplitudes of the pulses occupying the same space at the same time. He reminds the learners that interference can be positive or negative so interference can be constructive and destructive (LP). Constructive interference implies building up. Destructive interference means

		that one is bringing down (LP). The teacher then starts defining and discussing constructive interference and writes the heading on the board (CS). He reiterates that when constructive interference happens, it is when two pulses meet and the amplitude increases. He writes this on the board (TS). He points out that the amplitude which is formed is bigger than the amplitude of the pulses. He starts to draw a diagram (RP) to illustrate two pulses (A) and (B) before interference, both having different amplitudes. He illustrates that B is moving to the left and that A is moving to the right. He draws the resultant wave and its amplitude at the point of interference, illustrating that it is building and forming a greater amplitude. He then substitutes in mathematical values for A, which is 7cm and B, which is 3cm then the resultant wave would be A+B = 10cm thus there is a combination of the two amplitudes to form one (CS; LP; TS). The teacher explains that it is constructive interference because the pulses are both approaching each other on the same side. He explains that it is like interacting with someone nicely, it is a positive interaction. He asks if the learners are clear with what has been described (TS). The teacher then asks the learners what will happen after the waves meet and reminds the learners that they are approaching each other from different directions (WDT). The teacher states soon after, that after interference the one (pointing to B) will go to the left and the other (pointing to A) will go to the right and that they will then retain their amplitudes (WDT). He further elaborates what he has just said by drawing the diagram (RP) to show what the pulses would look like after interference, showing B as 3cm on the left and A as 7cm on the right still going in their original directions indicated by arrows. He asks if the learners are "fine" (TS).
6	21:41- 28:45 of video 1 + 00:00 – 03:00 of video 2	The teacher writes on the board the heading of *destructive interference* (CS). He asks the learners: "who can explain what destructive interference is?" (TS) He leaves the question unanswered and for the learners to answer. A learner answers by saying that it is when two pulses interfere and their amplitude, A and B subtract. The teacher then says, "they cancel each other" (TS). The learner agrees. The teacher asks if anyone else has another definition (TS). Another learner answers

		by saying "one negative, one positive coming from opposite sides and then coming together they combine..." then the teacher adds that their amplitudes become smaller. The teacher writes the definition of destructive interference on the board (TS). He explains that when they meet their amplitudes become smaller because they are cancelling each other. The teacher starts to draw destructive interference showing two pulses before they interfere up on the board (RP). The two pulses are of different sizes with different amplitudes. He also draws the resultant pulse during interference. After drawing the diagram, he asks the learners what the differences are between constructive and destructive interference (TS). He then states, soon after, that with constructive interference the waves are approaching each other and are both on the same side but in the case of destructive interference they are approaching each other from different sides. As a result of being on different sides, they are going to cancel each other, hence your amplitude gets smaller. He points out that if they take the first wave as positive, then the second wave will be negative. What it means is, that if the first wave has an amplitude of 7cm, then it is +7cm and the second wave will have an amplitude of -3cm because they are on different sides (TS). He describes the resultant wave and writes 7 – 3 = 4cm and further explains that they are thus seen to be cancelling each other out. He revises that constructive interference is "on one side and are building each other up" and with destructive interference "they are on opposite sides, so they are cancelling each other out" (LP). He further adds that with constructive interference, "it is increasing the amplitude" but with destructive interference "it is reducing the amplitude" (LP). The teacher then reiterates again what happens to the pulses once they have met and draws a diagram of it on the board (RP). He states that once they pass each other, they maintain their amplitudes (WDT). He asks the learners if there are any questions (TS). A learner asks: "For A and B for destructive interference, if A were to be 7cm, and B were to be 10cm, would you get a negative?" and "How would you then represent it?". The teacher answers by saying that the final amplitude will be negative and below the rest position because upwards is positive and below is negative. The answer will determine whether it is negative or positive and will show you which side the amplitude is. The teacher asks if it makes sense and

		if there are any more questions (TS). Another learner asks if it is possible for more than two pulses to interact at the same time. The teacher affirms that it is possible but it is "not for their level". He explains that it is the same principle because even if they meet and there are three or four of them, and are on one side, they will go up. If two of them are up and one is down, then the one down is negative and the ones up are positive, then the same principle applies (CS;LP). He asks if there are any further questions (TS). He tells the learners to go to their textbook, page 81, Activity 2 and to do question 1 and 4 (TS). The learners are given three and a half minutes to do the questions before the bell rings.  **Activity 2** Answer questions on interference and superposition 1 Explain what is meant by the following words or terms: interference, superposition, constructive interference, destructive interference. 2 State the principle of superposition. 3 Describe what happens when a pulse in a rope meets another pulse travelling in the opposite direction. 4 A pulse of amplitude –15 mm is moving to the right and one of amplitude +20 mm is travelling to the left. 4.1 Draw separate diagrams to show the pulses approaching each other; crossing and then moving away from each other. 4.2 Calculate the amplitude of the disturbance when they cross. 5 Table 1 shows the amplitudes of a number of pulses that approach other and then superpose as they cross. Calculate and give the direction of the missing amplitudes. (Positive (+) indicates the upwards direction.)
7	00:00 – 07:51 07:51- 17:39	Start of lesson 3a: The teacher is observed constructing the ripple tank apparatus for the first seven minutes and fifty-one seconds. I, the researcher, am also seen in the video assisting the participant by removing the individual items of the apparatus out of the box, handing it to the participant. I am also observed screwing the stroboscope handle onto the

		stroboscope and placing the D cell battery into the ripple tank controller. During which time, at around two minutes and thirteen seconds into the lesson, the learners are observed to accumulate around the apparatus seemingly interested in what the teacher is doing. At seven minutes and fifty-one seconds the teacher begins the lesson. The teacher reminds the learners that they have been learning about pulses which then make waves (LP). He introduces the learners to the ripple tank and reveals that the ripple tank is used to generate waves and to show how waves behave (RPRT). The teacher points out that in front of them there is a motor and inside the tank, is water. He indicates that he has put a small amount of dishwasher liquid into the water to make the water "soft", so that it responds to the things that he wants to do. The teacher reveals that they want to determine what happens to water when one produces a disturbance. He reminds the learners that there is going to be a movement of waves if there is a disturbance (LP). The teacher touches the surface of the water with his finger and says, "do you see what happens?" (RPRT; TS). The learners answer yes. The teacher does it again and describes that there is a movement of water and that the pulse is moving outward. He further says "that is what we call a disturbance, causing water to move". The teacher points out that the motor is going to cause vibrations and that vibrations are a continuous supply of pulses that form waves. He connects the ripple bar to the controller and asks the learners if they can see what is happening (RPRT; TS). He asks the learners what they are seeing (TS). A number of learners answer but under their breath. The teacher asks the learners to describe what they are seeing on the white paper that is placed underneath the ripple tank (TS). Soon after, the teacher states that they must say what it is they see and not what it is they think they should see (TS; LP). A learner answers that he is observing multiple pulses. The learners that were not originally intrigued, sitting in their usual seats far from the apparatus are now moving closer to the ripple tank. He asks again what the learners are seeing and moves onto explaining that there are lines that are moving across the water (TS). He further explains that from these lines, one observes light lines and dark lines (RPRT; TS; CS). He asks the learners if they are observing these lines he speaks of and the learners indicate that they are (TS). The teacher now asks the learners what the lines represent (TS). A learner answers that they are pulses. The teacher

		explains that when there is a continuous movement of pulses, a wave is formed. He further explains that when there is a light line, it represents the crest of a wave and when there is a dark line, it represents the trough of a wave (TS). He reveals that the "highest thing" is the crest and the "lowest thing" is the trough. He reiterates that the two important terms are known as the c*rest* and the *trough* and that the crests are represented as the light line and the troughs are represented as the dark lines (TS). He asks the learners what else they are seeing and allows the learners to answer (TS). No one answers and then the teacher asks if they are realising that the lines are not changing their size (RPRT). The learners agree. He reveals, that as long as the disturbance stays the same, the pulses will remain the same, and that the successions will be the same. He further adds that the pulse length is not changing, which also means that the *wavelength* (CS) is not changing. He asks the learners if "we are together?" (TS). He reveals that it is for that reason that the lines are staying the same. The teacher then indicates that he wants to increase the speed of that "thing" while pointing to the ripple tank bar and motor and tells the learners that they need to tell him what they think is happening (TS). While turning the controller knob, there is silence and he asks again: "what are you seeing?" (RPRT; TS). A learner answers that the crests and troughs look smaller. The teacher repeats after the learner stating: "so the crests and troughs look smaller as I increase?" (TS). The learner answers "yes" and continues to say, "that means that wavelength is smaller", using his fingers to illustrate. The teacher agrees and says that the wavelength is decreasing. The teacher then reduces the frequency by putting the controller back to the original frequency. The same learner answers by saying that "they" look bigger. The teacher then asks the same learner what he could say about the relationship between the two, specifically mentioning wavelength (LP; TS; CS). The learner starts answering by saying "the more…" and then stops. The teacher says, "okay let us answer the first question, the first question is": "If I increase the vibration what is it that I am increasing?" (TS). The learner replies that the teacher is increasing the number of pulses per second. The teacher says "good" and then asks again, what am I increasing. The learner responds with the same answer and the teacher says, "don't you think it is *frequency*, which is the number of waves per second which is being increased" (TS). The learner agrees. The teacher then asks the second question which is "explain the relationship between frequency and wavelength" (CS; TS). No one

		answers. The teacher then specifies that a low frequency causes…while pointing to the demonstration using the tank (RPRT)...no one answers. The teacher using the controller changes the frequency again and says: “this is higher frequency which causes what?” and the learners answer that it causes smaller wavelengths (RPRT; LP; TS). Then the teacher reduces the frequency and the learner states: "it is a bigger wave". The teacher repeats what the learner said but using the correct term of "bigger wavelength" (LP; TS). The teacher then re-asks the class for the relationship between frequency and wavelength (TS). A number of learners are heard answering, but the clearest voice is heard saying “the higher the frequency the lower the wavelength”. The teacher repeats after the learner and points out that the higher the frequency, the shorter the wavelength, or the lower the frequency the shorter the wavelength (the learners are heard repeating after the teacher). The teacher reminds learners that if they are talking about wavelength it is either "shorter" or "longer" (WDT; TS). The teacher concludes that frequency is inversely proportional to wavelength (TS). He asks the learners what the statement means and what inverse means (TS). A learner answers "the opposite". The teacher explains further that it means that as one increases, another decreases or if one decreases the other one increases and that it explains the relationship between frequency and wavelength. He asked if the learners are "sorted" (TS). The learners indicate that they are.
8	17:40 -22:17	The teacher asks the learners if they are able to identify the shape of the waves (TS). Soon after, he reveals that they are linear because the vibrations are produced, using a linear object. The teacher places the two circular balls into the ripple bar (RPRT). At the same time a learner asks: "what happens if you put another wave 2m away?" The teacher misinterprets the question and says that it is when one changes the vibrations. The learner makes his question clearer by asking if one puts another wave on the other side (the learner illustrates what he is asking by using his hands which are seen to move towards each other. He then claps his hands together while moving them up as a sign of the waves then meeting and hitting each other). The teacher implies that that is when one would see *superposition*. The teacher places the two circular balls onto the surface of the water making sure that the ripple tank is nicely setup (RPRT). He starts the vibrations. He then asks the learners what they are seeing (TS). A learner answers that he is seeing circular waves, while another learner

		uses her finger to illustrate a circular pattern. The teacher then further states that there are two different waves. The learners agree, and that they are circular. The teacher asks the learners if they can see the pattern (TS). The teacher also points out that the waves are meeting, while the learners are seen indicating this by pushing their hands together. The teacher is observed trying to see the effects of superposition using the stroboscope in front of the learners (RPRT). A learner asks if the two waves are linked to each other. It is observed that the teacher is battling to see the phenomena through the stroboscope. The teacher then asks the learners if the learners are seeing the pattern down on the white paper and the learners indicate that they are. The teacher asks the learners whether they can see where the waves are meeting (TS). The teacher then moves onto another demonstration.
9	22:17-26:42 of video 1 + 00:00-06:17 of video 2	The teacher reveals that he wants to show the learners what waves do when they reach a barrier (CS). The learners are seen talking about waves and the patterns seen while the teacher adjusts the ripple tank for the next demonstration. The teacher lowers the ripple tank bar after removing the balls and places two metal long barriers into the tank, forming a very small gap between them. (RPRT). He attaches the ripple tank controller and switches on the light. He then moves the barriers slightly more apart and then slightly closer together and then removes a barrier leaving a single barrier in the centre of the tank (RPRT). He asks the learners what it is they observe (TS). A number of learners are heard answering, while other learners are observed using their hands to explain what it is they see. Their responses are not clearly heard. The teacher allows the learners to continue to discuss what it is they see with one another. The teacher then starts to explain "because of the barrier the waves…". He then asks the learners what else they are seeing (TS). Again, there is a lot of discussion amongst the learners. He leaves the question unanswered and then asks the learners what is observed if he places another metal barrier into the tank (while forming a gap between the two) (RPRT). Again, further discussion amongst the learners is heard. One learner is heard saying that the waves are "passing through". The teacher asks the learners if they can observe that the waves are passing through. He further asks what it is that the learners are observing when the waves are passing through the gap (TS). One learner describes that "they" have become

		bigger. Other learners answer by saying that "they" are observed to be smaller. The teacher steps in and illustrates, using his arms and hands, that *rainbow shaped* lines are being formed, after which a learner says the word *Arc* and that "they" are forming an *arc* (TS). The teacher moves the metal barriers further apart, forming a bigger gap and asks the learners if they observe any difference when he does this change (RPRT; TS). The same learner says that the arc increases. The teacher tells the learners to look on the paper under the tank and asks again if there is any difference. He asks if they can see the pattern that is "there", using his finger to point to the pattern (TS). He then moves the metal barriers back closer together (RPRT). The same learner states that the arc has become smaller. The teacher then reveals after that, that when it was more open, the lines are seen to be "more straight" and that when it was closer, the lines are "more rounded" (which is illustrated through his hand movements making a rainbow shape) (TS). The teacher then asks the learners what "this" is called, when a change in the wave happens because of a gap (TS). He allows the learners to answer, and reminds the learners that they did this in grade 8 NS (LP). The learners sound surprised. The teacher asks the learners if they have never heard the term *diffraction*, after which they answer no. The teacher asks the learners if there are any questions (TS). At this point some learners are engaged, while other learners are heard having their own conversations. These learners are missing the questions asked by other learners. A learner asks the teacher what is meant by the term *diffraction*. The teacher answers that it is the bending of waves when they pass through an opening. Another learner asks a question but is not heard, however, the teacher is heard answering that "the higher the frequency the shorter the wavelength". The same learner then reiterates that they become shorter. The teacher agrees and reveals that the wavelength becomes shorter. The same learner then asks "do they not become thinner?". The teacher specifies that thinner means shorter (LP). The teacher reminds the learners that when one is talking about wavelength it means that they need to use the terminology *longer* or *shorter*. Another learner asks: "what is the use of the barrier in a real-life situation?". The teacher answers while pointing to the classroom projector (TS). The learner then asks if there are waves inside the projector. The teacher implies that there are. Another learner asks whether the ripple tank has glass as its tank and the teacher responds that it is. Another question is asked by a learner but is not heard. However, the teacher is heard answering "frequency is inversely

		proportional to wavelength". The teacher asks if there are any further questions (TS). A learner is heard asking why in the sea, waves are seen as going up and down. The teacher's response cannot be heard because the bell rings. Some learners are still interested after the bell rings and are seen to congregate around the ripple tank. They are heard asking further questions but are not heard clearly. When the teacher responds, their enlightened faces indicate that their questions have been answered.
10	00:00 – 04:43	Start of lesson 3b: The teacher starts the lesson by illustrating the phenomenon of superposition, constructive and destructive interference again, using the ripple tank apparatus (RPRT). This time around, the classroom lights are switched off. The teacher suggests to the learners which angle he believes the phenomenon is best seen, which is in front of the ripple tank on the other side of the ripple bar. The teacher shows the learners the lines that are coming out from the circular balls, seen on the white paper under the tank (RPRT). A learner responds by saying that what he is seeing in the tank is also being observed and projected on the roof. The teacher focuses on the white pieces of paper underneath the tank and shows the learners the lines which he terms as "empty" and that at those lines there is "nothing there". The teacher reiterates where it is best seen. The teacher explains to the learners that where they are observing lines, constructive interference is occurring and where they are observing the "empty lines" it is where destructive interference is occurring. A Learner is heard confusing the two and asks the teacher to repeat himself, which he does. The teacher points out that the waves are moving and spreading. A learner is heard saying that it is "beautiful". The teacher reveals that he wants to do something else; which is to discuss the transverse wave. The learners resettle, while the teacher sets up his textbook to start teaching from the board.
11	04:44- 17:50	The teacher writes the heading of *transverse waves* on the board. He reminds the learners that a wave is the succession of pulses (LP). He further mentions that there are two types of waves, longitudinal waves and a transverse pulse (LP). The teacher writes on the board that a transverse wave is a succession of pulses. The teacher asks the class "which are

		the transverse pulses?" (TS). A learner responds that transverse pulses have particles that move at right angles. The teacher repeats after the learner saying, "transverse pulses have particles that move at right angles to the direction of propagation" (TS). Next to the definition on the board he puts an example of water waves (LP). The teacher is then observed to draw a diagram of a transverse wave on the board (RP). A learner asks the teacher if what is drawn on the board, is a transverse wave. The teacher answers "yes" and then the learner proceeds to ask: "where are the right angles?". The teacher replies by saying "I will get to that". The teacher is seen to label the diagram by putting in the labels of *rest position*, *crest*, *trough*, and *wavelength* from trough to trough, from crest to crest and from one point in phase to the next point in phase (RP). He writes Lambda as its symbol, in brackets after the word wavelength. The learners are given time to copy the diagram and labels from the board (TS). The teacher is then observed adding the label of *amplitude* showing that it is from the rest position to the crest and from the rest position to a trough. Before the teacher explains the diagram, the learners are heard saying the word *Lambda*. The teacher then asks if the learners are done drawing (TS). A learner asks what the funny symbol represents, seen on the board. The teacher answers by saying that it is *Lambda* and that it is the symbol for wavelength. The teacher reveals that what the learners see drawn on the board, is an example of a transverse wave. The learners are quite talkative. This prevents me and the other learners from hearing the questions posed by the other learners. However, the teacher is observed to answers the questions asked by the learners. The teacher continues talking about the transverse wave. He indicates that the highest point or maximum point on a transverse wave is the crest and the lowest point on the transverse wave is the trough (TS). He shows that the distance between two crests is the wavelength. Furthermore, that the distance between two troughs is also termed the wavelength or even where a wave starts, to where it starts to repeat itself, is also known as a wavelength (WDT). He points out that the learners must look for the crests or the troughs or where it repeats itself to measure the wavelength (WDT). The

		teacher then shows the rest position and asks the learners "what is the rest position?" (TS). A learner answers saying that it is where the waves is, before a disturbance. The teacher specifies that the rest position is where the particles will stop when there is no disturbance. The teacher illustrates using the diagram on the board where rest position is and that when a disturbance occurs, it is at that point that a wave starts to form (moving his finger over a crest) (RP). The teacher shows, using the diagram, the particle movement from the start of the wave and how the particles would move. He also illustrates using his finger on the diagram the meaning of *one complete wave* (CS; RP). A learner asks: "will the particle rest for like a second?". The teacher responds by saying that the particle does not rest as long, as there is a disturbance. He reminds the learner that a disturbance is a succession of waves and that there is a continuation (LP). Using the diagram and his finger he moves along a complete wave and then the next complete wave and the next but which is only half a wave (RP). The teacher then says that if he has to ask the learners how many waves there are in the diagram what would the learners answer? (TS). He allows the learners to answer (TS). They respond by saying: two-and-a-half waves. The teacher repeats the phrase of two-and-a-half. It can be heard that some learners are confused. The teacher allows the learners to argue and discuss before showing again on the board using his finger why the answer to his question is *two-and-a-half* (TS). The teacher reveals that the reason why he is showing the learners how to determine the number of waves is because there are going to be calculations where they will be required to calculate frequency. (CS) The number of oscillations is required for such questions. The teacher points out that they are now going to write down definitions.
12	17:51 -25:45	The teacher starts with the definition of *amplitude* (CS). He shows the learners, using the diagram, the label of amplitude and states: "it is from the rest position either going up or going down, it is not from up to down" (WDT). A learner asks if it starts from a rest position and the teacher reiterates that it starts from the rest position. The teacher reiterates that if the learners are calculating amplitude that it must be from the rest position going up or going down (WDT). He asks the learners if they are "fine" with what has been said. He further adds that he will be able to show learners other learners that will make the mistake of taking amplitude from "top to bottom" (WDT). A learner asks that if they are asked about the amplitude, whether they need to stipulate the direction of the amplitude. The teacher implies that amplitude is stating

		how far it has gone from the rest position and that whether it's up or down, the result is the same. A learner asks that if they are given the value from "up to the bottom" would they divide by two. The teacher specifies that they would. He reiterates that if he gives the learners the distance from the crest to the trough, they must divide that value by two because the value from rest position up to the crest or down to the trough, is the same. A learner asks the teacher if a wave comes from the opposite direction, just like the one shown on the board, would it mean that Superposition would occur. The teacher explains that it will depend on how they meet. If they meet at the same point at the same time. He further adds that if all the top parts meet and then all the bottom parts meet at the same time, then constructive interference would occur. If the crests and troughs meet, it will be destructive interference that occurs and then it will become "flat" (showing by the movement of his hands). The teacher reveals that they are now going to define a *crest* (CS). A learner asks about interference and the teacher is heard stating that interference is when they meet and that it would occur if a wave was coming from the other direction. He is seen to explain further that if the crests meet, it will be constructive but if it's the other way around, it would be destructive and become flat. The teacher starts to define a *crest* as the highest point on a wave and the learners start writing in their books. The teacher specifies that in brackets they can also write the term *maximum point*. He defines a *trough* as the lowest point on a wave. He suggests that in brackets the learners should also write the term *minimum point*. The teacher then moves on to the term *wavelength* and that it is the distance between two successive crests, or troughs and is measured in metres and has the symbol as shown on the board, known as Lambda. A learner asks the teacher if wavelength is measured in metres only and the teacher indicates that they may have to do a conversion to metres if the value is given in centimetres (LP; CS). He reiterates that Lambda is the symbol for wavelength. He defines the *rest position* as the position where the particles of a medium stop when not disturbed.
13	25:46- 28:03 of video 1 + 00:00 - 11:41 of video 2.	The teacher writes the word *in-phase* on the board and implies that he is now going to give the definition of 'in-phase'. He explains that it is when two points on a wave move in such a way that they are at similar positions at the same time. The teacher adds to the diagram that is on the board (RP). He places point A on the one crest and point B on another crest and reveals that these are examples of in-phase points (TS). The teacher draws point C on the first trough and then point

		D on the next trough and that these points are another example of in-phase points. The teacher then draws two additional points E along the rest position before the start of the crest and point F where the waves is about to repeat itself (RP). He indicates that they are also examples of in-phase points. The teacher writes the word *out of phase* on the board (CS) and points out that the next definition is regarded as 'out of phase'. He explains that it is when two points on a wave move in such a way, that they are not in similar positions. The teacher then draws point G which is placed halfway from a trough going up towards the rest position and then compares point G to point A (which was drawn on the first crest) (RP). He explains that they are out of phase because they are not in the same position at the same time. He draws in another point, Point H, at the rest position before it starts to move down to a trough and asks the learners whether Point E and H are *in-phase* or *out of phase* (TS). The learners answer that they are in-phase (which is incorrect because E is about to move up to a crest whereas H is about to move down towards a trough) but the teacher allows the learners to discuss this amongst themselves (TS). A learner then indicates that they are actually out of phase. The teacher asks again whether the two points are in or out of phase (TS). The learners respond saying that they are out of phase and the teacher asks the learners to explain the reason (TS). A learner explains that point E is moving up and point H is moving down which means that they are not in the same position. The teacher reminds the learners how and in which direction the wave is moving in order to illustrate why point E is moving up and why point H moving down (TS). The learners then understand and the teacher asks if the learners are getting the point. They indicate that they are. The teacher asks the learners if they understand 'in and out of phase' and indicates that it is not about being on the rest position but also the movement of the particles (WDT). The teacher looks at his textbook and tells the learners to go to page 83, Activity 1 and to do question 4, 5 and 6 (Image not taken) (TS). The learners are given four minutes and thirty-nine seconds of class time to do the activity. The teacher uses the time to start dismantling the ripple tank apparatus by removing the battery of the controller.

APPENDIX N: TRANSCRIBED SCRIPT FOR THE VIDEO-STIMULATED RECALL INTERVIEW, JESSICA

INTERVIEWER: Okay. So it's still the 14th of March and we're about to go into the video stimulated recall interview with Participant A. Okay. So basically what this is about is I am reminding you of the lessons and I'm asking you questions on them. If you recall the… the question that I'm asking you, I don't need to show you the audio. You can tell me that. That's okay, I record this and you just answer it. If you don't recall it, then we'll go back, I… we go and look at the audio and obviously the visual and then we discuss it afterwards.

INTERVIEWEE: Perfect.

INTERVIEWER: Okay. So what I'm going to first do is I'm basically just going to skip or… not skip but skim through the whole video where you just see your movement through the video and then I'll ask you the… the relevant questions.

INTERVIEWEE: Perfect.

INTERVIEWER: Okay. Okay. So when we skim through can you see there?

INTERVIEWEE: Yeah.

INTERVIEWER: Perfect. Okay. [Audio: Lesson 1 was skimmed through with the participant] So through that skim, what teaching methods and activities did you see yourself using during that lesson?

INTERVIEWEE: Okay. So from… I did spend a lot of time in the front of the class. So if you play it through like that to me that it kind of shouts like telling your lecture, but I don't necessarily believe that I do… do that because there is a lot of question and answers that you don't obviously see through your skim. So that would then be more…

INTERVIEWER: You don't even have to worry about that much okay.

INTERVIEWEE: A facilitator. So I think it's more like that with obviously some demonstration in the middle part.

INTERVIEWER: Okay. And what…

INTERVIEWEE: So the demonstration broke the facilitator/lecture…

INTERVIEWER: Awesome.

INTERVIEWEE: On either side.

INTERVIEWER: Perfect. And what activity did you do at the back of the classroom?

INTERVIEWEE: Okay. So at the back of the classroom I took the learners and we did a demonstration using a slinky spring about the… a simple wave cycle or multiple cycles of a wave.

INTERVIEWER: Cool. And then when you look at this video…

INTERVIEWEE: Yes.

INTERVIEWER: You were in the front of a class, and what were you first doing with your learners?

INTERVIEWEE: Okay. So in the very beginning…

INTERVIEWER: Right at the beginning.

INTERVIEWEE: The very beginning I was collecting homework. So we had to collect essays, because we had a essay due and then we did like questions and answers and we started out just getting the general idea of how they… what they understood about waves? What they think about when they think of a wave? And we progressed from there into the different things about waves.

INTERVIEWER: Brilliant. And then you can see yourself ending here and what have you ended with?

INTERVIEWEE: I've ended with a wave… so a simple diagram of a wave where it's a 2D wave, single wave going or propagating through a medium.

INTERVIEWER: Thank you.

INTERVIEWEE: And it's not specified.

INTERVIEWER: Perfect.

INTERVIEWEE: And it's all labelled and annotated.

INTERVIEWER: Brilliant. Perfect. Okay. So explain your reasoning of doing the definitions and getting some ideas with the learners and then going to the back to do the slinky and then going to the board to do the diagram. Just explain your reasoning about that.

INTERVIEWEE: Okay. So I like to make sure that the learners can relate to what I'm talking about. So in order for them to actually make meaning of what they're doing say on the slinky, on the board, they need to know what I'm talking about. So that's why I really try and make sure especially in the section because they do confuse terms, that they understand what the difference is between the terms and they start getting familiar with me using those terms because obviously it's going to be… this was their initial intro to waves. So it was the first lesson. They will be using it for the rest of the section. So they did need to know those terminology and make sure that they were fully aware of what I was talking about when we spoke about it. Then to take them to the back of the class that was to create image that they could refer to mentally when they are revising, when they are studying and if they want to try it at home, they can also try it at home, because it's something they can actually access when they are at home. Obviously, they might need to buy a slinky, but the same effect can be achieved with a rope. And then at the end we took it back to the board because that's most common how they are going to be assessed so putting it in a format that they can be now be familiar with for any assessments.

INTERVIEWER: Okay. Now I don't know if you recall but when you move to the back to introduce the learners to the slinky how did you approach trying to understand and gain their prior knowledge?

INTERVIEWEE: Okay, ya I am not entirely sure, lets see what I did? I don't want to lie.

INTERVIEWER: Okay. No perfect, so let's go [Audio: Participant is using the slinky at the back of the classroom and generates a wave and askes the learners- what can you say about that wave? What can you say about the slinky? Allowing learners to answer in their own words and terminology]. So what… what… what do you do there?

INTERVIEWEE: So I was asking them to relate it to something and describe what they were seeing. So try and describe what was happening in their own words. That was how…

INTERVIEWER: Exactly.

INTERVIEWEE: The way I got them to talk about it.

INTERVIEWER: Perfect. And I just observed with you asking the questions, you… you left the learners to then answer in their own terminology.

INTERVIEWEE: Yes.

INTERVIEWER: And allow them to come up with whatever they saw in their own words.

INTERVIEWEE: Yeah.

INTERVIEWER: Perfect.

INTERVIEWEE: I find that's useful.

INTERVIEWER: Okay.

INTERVIEWEE: If that's in their own words, they're able to explain it to themselves.

They understand what they're saying because they've said it. So they more likely to understand something if it is there the way that they can explain it.

INTERVIEWER: And understand it, I suppose.

INTERVIEWEE: Yeah.

INTERVIEWER: Okay. So now I'm going to play you a clip at 00:21:00 through to 00:22:53. Okay [Audio: The participant explains the length of one wave and a pulse – learners are asking questions because they are getting confused as to what a wavelength and pulse is and where the wavelength can be measured from. The participant addresses their concerns]. So in this clip I'm going to ask you two questions.

INTERVIEWEE: Sure.

INTERVIEWER: The first is you are… it's the first time in the lesson that learners are starting to ask questions.

INTERVIEWEE: Yeah.

INTERVIEWER: How… what question or misconception is observed here?

INTERVIEWEE: Well they're confused between like the wave length being for what a pulse is or when it's an actual cycle versus the actual entire wave in my understanding.

INTERVIEWER: Exactly. Perfect. And how did you address this misconception?

INTERVIEWEE: Well I tried to highlight the fact that it only refers to one cycle and a pulse is the same as saying one wave cycle and I'm not entirely sure what I said after that, but pretty much I was trying to make sure that they… there often can be more than one wave cycle drawn. So the wave length is not the entire distance of the whole wave being covered. It's just of one cycle as if there was just one pulse there. That's what the wave length is, what referring to.

INTERVIEWER: And do you think it was important to have that drawing on the board to explain it?

INTERVIEWEE: I think it would have been necessary. So if that drawing wasn't there, I probably would have drawn it to make sure that it was clear.

INTERVIEWER: Perfect. Okay. So you've already based or touched on… on the learning and teaching style of this. So looking at lesson one as a whole, what do you believe the… the teaching style was?

INTERVIEWEE: According to those, I think… I would have… I would have… would hope it's closer to facilitator then say something like a delegator, although delegator does some fancy but I think that the way that I have approached it, I do try and make sure that they make their connections. I do try and help them make sure that they did think by themselves and allow them the freedom to ask and find their own answers. So I based on, what I can remember what I've just seen, I do believe that was my approach.

INTERVIEWER: Perfect. And when you look at this, even though the ripple tank wasn't used, you still used different representations.

INTERVIEWEE: Yes.

INTERVIEWER: Just list them for me, what… what representations you used in this lesson.

INTERVIEWEE: Okay. So in this lesson I used the slinky and I used the diagram. And some of the kids actually themselves did the wave from the Mexican wave, when they were trying to explain what was going on.

INTERVIEWER: Brilliant. Perfect. And do you find through that were your learners engaged in this lesson?

INTERVIEWEE: I think they were. Yeah, I think it… it definitely does help when they can actually see the different formats that it can be especially because often sciences when they see concepts, they literally just think about it as what is happening on the paper. They don't really relate it to real life. So taking something in… something that's real life like a slinky, it kind of can make it a bit more relatable. So then they seem to be a lot more interested in it.

INTERVIEWER: Brilliant. Okay. So now we're going to go to lesson two. Okay. Again I'm just going to skim through.

INTERVIEWEE: Perfect.

INTERVIEWER: The beginning I just started recording really early. You're still doing announcements and things like that.

INTERVIEWEE: Yeah.

INTERVIEWER: So you'll only start seeing the lesson begin quite a bit later in this clip, but… so that… it actually starts from 00:04:32 [Audio: Lesson 2 was skimmed through with the participant].

INTERVIEWEE: Okay. Late students.

INTERVIEWER: Okay.

INTERVIEWEE: Cool.

INTERVIEWER: So at 19:40…

INTERVIEWEE: Sure.
INTERVIEWER: You start to introduce the ripple tank…
INTERVIEWEE: Yeah.
INTERVIEWER: As a representation. I noticed through this clip and through the observation that you jump straight into demonstrating the phenomena of interference, reflection, refraction, diffraction and repeating the whole thing again with circular waves. And you didn't spend too much time on the… on using the ripple tank to explain frequency and wave length and the relationship between the two.
INTERVIEWEE: Okay.
INTERVIEWER: Explain to me your reasoning of doing what you did.
INTERVIEWEE: I think because also in that session obviously the… the topic of that session was mostly doing the different properties, it was different properties of the waves. That was my main focus. But I also think that with changing the frequency and with getting them to measure the wave length, because it's difficult to see and because it will have the spinning thing… what's it called again?
INTERVIEWER: Stroboscope.
INTERVIEWEE: Stroboscope. I always want to call it a spectroscope, but I know it's wrong. Because I didn't have the stroboscope, I didn't think they would be able to really see that clearly. So… and I did actually with the girl who did actually slow motion this, I did do a lesson later on it and said "look you can actually see how the wave length is changing here" and we did actually break down those videos. But in this session I think because it was… it is quite difficult for them to actually physically measure the wave length because it's obviously a moving wave verse a static wave on a diagram, it's quite difficult for them… for me to try and teach them and to show them because they also get so distracted by the lines moving across the table, that they do get… I think they might have lost it. But I could have supposedly could have change the frequency up a bit and I think I did try, but I was also scared that they wouldn't see the effects that I was trying to show with the properties by changing the frequency too much.
INTERVIEWER: Perfect. And then mention… please mention again why your school particularly compare to other schools…
INTERVIEWEE: Yes.
INTERVIEWER: Does cover reflection, refraction, diffraction in Grade 10.
INTERVIEWEE: Okay. Well we cover it in Grade 10 specifically in this year

because Grade 11 and Grade 12 we focus on the concepts that covered in the SAGs. So because waves is not part of the IEB Curriculum anymore, we have the time in Grade 10 to cover it and we feel that it is something nice for them to do because it's actually relevant in their real life and should they want to go into anything that does relate to waves say like fibre optics or like anything fibre related, they will need to understand those concepts. There's also other jobs that require those and the understanding of refraction and reflection and diffraction and interference and all of those, especially if they want to say go into sound and music. Those are all essential skills that they might need to actually use in their real life. So we feel that it's a quite… well we as the Science Department feel that it's quite a nice topic to do because it's relevant to them. They do enjoy it and it could possibly be useful in their future careers.

INTERVIEWER: Awesome. Perfect. Okay. So now I'm going to the second clip and I'm going to 00:08:03. [Audio: The participant is heard asking the learners what they think will happen before she does the illustration using the curved barrier. Learners are left to answer and then they discuss what they think will happen. The teacher demonstrates using the ripple tank and learners are heard to be excited by what they see. The teacher states that their predictions are correct] Okay. So two questions.

INTERVIEWEE: Okay.

INTERVIEWER: In that clip you… you say to your learners "what do you see? What do you observe?" Is it something you have always done or is it something that you did learn or pick up from the training?

INTERVIEWEE: It's something I've… I think I've always done, but I do think I was more aware of it because of the training. So I have always tried to get the learners to think about it and try and come up with their own answers and then see if they're right. But I do think especially with this section, I was a lot more aware of the fact that it's nice to get them to tell you what they know. Because then you can see what they don't know.

INTERVIEWER: Brilliant. And then in this clip you see yourself demonstrating reflection using a curved surface. Is that something new because of the training or again is it something you've always shown these in the ripple tank?

INTERVIEWEE: So usually we do show them just because even though we don't really focus on curved surfaces and say lenses or anything like that, it may still… it is

still something that is useful. So even though we don't really go into the fine details of it, we do cover it briefly. But in this session it was just… to just extend them further. So when we do go through lenses, they will probably see it again, but in this session it was just like now what happens if it curved? So that was just an… almost an extension question of what they can… what they were predicting.
INTERVIEWER: Okay. Perfect. Then you mentioned previously that you like to use the light kit. Now in the lessons I personally observed, I didn't see you use the light kit. Did you end up using the light kit or did you decide to remain with the ripple tank for your Grade 10's?
INTERVIEWEE: Okay. We did end up using both.
INTERVIEWER: Okay.
INTERVIEWEE: So because the way we do teach especially the properties like refraction and reflection, we do use both because they need to be able to do the 2D like… so like not a 2D, a single wave, so like an easy represented like by a beam of light as well as a plainer wave which is obviously easily represented on the ripple tank. So for instance we have done the reflection and they did actually experiment one with the ripple tank and one with the… with the light box and got to the same conclusions.
INTERVIEWER: Brilliant. So you actually use both of them…
INTERVIEWEE: Yeah.
INTERVIEWER: To get the same conclusion.
INTERVIEWEE: Yes.
INTERVIEWER: Brilliant. Okay. At 00:22:45, like with the other one…
INTERVIEWEE: Yeah. 45, 00:22:45.
INTERVIEWER: Okay. So in this clip you… when you show them their reflection, that one learner says the word "trippie" was used.
INTERVIEWEE: Yes.
INTERVIEWER: I'm going to play it for you, but I want you to tell me what this means.
INTERVIEWEE: Okay. What the word means? [Audio: Learners are heard saying the word "trippie"]
INTERVIEWER: Okay. So when those learners say the word "trippie", was does it actually mean?
INTERVIEWEE: It means from what I understands that for them it's something very

odd to watch. It's very… it's something odd to see and as if it's like they're hallucinating. It's if their eyes are playing tricks on them. So it's slang… it's kind of… got like the connotations of getting high that's kind of imagine things that maybe shouldn't be there for them when… especially when they first play with the ripple tank. They always seem to say that it's "trippie" because it's like their eyes are playing tricks on them.

INTERVIEWER: And what does it indicate? Is it… does it indicate that they're bored or do you think that it really just indicates that it's… they are amazed with what they're seeing?

INTERVIEWEE: Yes. It's… it's definitely amazed of what they see. They don't… they're seeing what they're seeing and they don't understand what's going on. So it's not because they're confused. It's because they… their mind is at seri… I feel seriously being challenged… it's been ideas that they had and now being tested.

INTERVIEWER: And which is what we want.

INTERVIEWEE: Yeah.

INTERVIEWER: Okay. So at the second clip, at 00:04:15… okay at 00:04:15 you get the learners thinking when you describe a slit and falling rice and what they think they would observe. This was very similar to the example that was used during the training of the same thing but using sand. Have you always used this example or is this something you took from the training?

INTERVIEWEE: I did take that from the training. Yeah. Because I never usually made the… like made them think about particle verse wave properties. So I thought that was very useful in the training. So I did take it over.

INTERVIEWER: Brilliant. Was your lesson, this particular lesson, effective and if so, or if not, how do you know?

INTERVIEWEE: I think it was effective because this was an intro to the properties and by the end of that lesson, they had… they were… I was… they were be able suggesting scenarios. They were setting it up and then before they could try it out and see what actually happen, they have to predict what happen and most of the times they got it right. So I think that they… they did… it was effective. They seemed to have learned the different properties. They could predict what they could expect was going to happen quite accurately. So I think it kind of achieved what I hoped it would have achieved.

INTERVIEWER: Brilliant. And that basically answers the next question. I was going to play to you at the end you got the learners involved and you made them come up with a scenario but you said to them "you only take part into a scenario if you've got the answer for me".

INTERVIEWEE: Yeah.

INTERVIEWER: What is your reasoning for getting the learners to do that at the end?

INTERVIEWEE: Well I like… I like them to think about it before they just go. So obviously there's merit in just going, because if you… if they just go and they just set it up then they can learn. But they need to… I'm… I'm trying to get them to force… well to force them to think about what's actually happening before they just watch it and say "oh that's cool" and move on. Where if they thought about it, they're actually are trying to process what's going on, trying to remember what they've learnt and actually apply it and see if their application of their understanding is correct. And then if it's not correct that we corrected it. So I think it's a better way of then to play because they play but they have to play with logic in a way.

INTERVIEWER: With reason.

INTERVIEWEE: Yes.

INTERVIEWER: With reason. 100%

INTERVIEWEE: Yes.

INTERVIEWER: Perfect. Then in this lesson, because it was your first lesson that you used the ripple tank that you were trained on, were you confident in using it?

INTERVIEWEE: I suppose there's never… you're always never really confident. I did know what I was doing and I was fairly… I mean I felt prepared for that lesson, but there's always a little bit of thing that you sit there afterwards and say "oh maybe I should have done that. Maybe I could have done that". So I supposed that comes around too.

INTERVIEWER: Okay. So then if I…

INTERVIEWEE: And maybe not…

INTERVIEWER: If I re-put the question, were you comfortable in using the ripple tank after the training?

INTERVIEWEE: Yeah.

INTERVIEWER: So if you hadn't had the training were you… would have… would you have felt as comfortable?

INTERVIEWEE: Well if I still have the old ripple tank I would have been okay because obviously I've taught with that one for two years, but if I had just this new one and I hadn't been trained on it, I'd probably would have been okay. I feel I'm quite good at wigging things, but I obviously wouldn't have been as confident as I was without the training.

INTERVIEWER: Okay.

INTERVIEWEE: Yeah.

INTERVIEWER: Okay. Great. So now we're going to move your last lesson, lesson three. Okay. So again I'm going to…

INTERVIEWEE: Skim through.

INTERVIEWER: Is this the right one? Yeah. Okay. So I'm going to skim through.

INTERVIEWEE: Yes.

INTERVIEWER: Just to remind you basically in essence what happened.

INTERVIEWEE: Yeah. Very necessary. [Audio: Part 1 of lesson 3 is skimmed through with the participant]

INTERVIEWER: Okay. And then the second one. [Audio: Part 2 of lesson 3 is skimmed through with the participant] Okay. So in this lesson, what representations did you see yourself using?

INTERVIEWEE: Okay. Well I used the slinky. I used the board and I used the ripple tank. So three different representations and I'm pretty sure I used the diagram and the… a simulation as well.

INTERVIEWER: Perfect. Right. At 00:05:15.

INTERVIEWEE: Slinky question. No. [Audio: The participant used an analogy of 'destructive' being bad and 'constructive' being good. A learner asks if destructive interference is therefore bad interference with constructive interference being good interference.]

INTERVIEWER: Okay. So in that clip you see a learner actually taking what you say quite literally.

INTERVIEWEE: Yes.

INTERVIEWER: And perceiving it as a misconception. So how did you address that whole situation?

INTERVIEWEE: Okay. Well I tried to highlight the fact that it was just an analogy and I use analogies quite a lot. Often they're quite okay with that, but I did highlight the fact that it was just an analogy and it was just to help them make sense of the words in case they get them confused.

INTERVIEWER: Great. Perfect. Okay. So now we're going to 00:08:45 [Audio: The participant had the learners at the back of the class to demonstrate constructive interference using the slinky spring. She asks the learners after demonstrating using two pulses and if they can see what is happening with the pulses? The learners keep referring to the idea that the pulses bounce back once the pulses meet. The participant continues to probe, asking further questions to try get the learners to understand the concept of constructive interference and that the pulses meet and continue along their original path at the same height as before].

INTERVIEWEE: The kids are distracted.

INTERVIEWER: Okay. So in this representation…

INTERVIEWEE: Yeah.

INTERVIEWER: Using the slinky was it easy to see the phenomenon…

INTERVIEWEE: No.

INTERVIEWER: Of constructive interference?

INTERVIEWEE: No. But sometimes we have a metal slinky. We have… we have lost our metal slinky. So usually we do this with a metal slinky because it's longer and then can actually like it's not so quick because they do have the space to actually see it travelling and usually you can see it quite nicely because of the metal. It's also heavier. So it's not as easy to slide. So usually the metal slinky is a bit better but admittedly the plastic slinky isn't great.

INTERVIEWER: Perfect. And do you recall through this clip that because you identify that the learners were not seeing what they needed to see, you were prompting them through questions?

INTERVIEWEE: Yes. Yes, I was.

INTERVIEWER: Okay. And eventually, basically towards the end of this, you'd… you basically had to tell them what they are meant to see…

INTERVIEWEE: Yes.

INTERVIEWER: And then once they knew what you see…

INTERVIEWEE: Yes.

INTERVIEWER: They were then able to see it…

INTERVIEWEE: Yes.

INTERVIEWER: In this particular situation.

INTERVIEWEE: Exactly yeah.

INTERVIEWER: And you know there could have been different examples, but in this particular one it was just… they were battling to…

INTERVIEWEE: Yes.

INTERVIEWER: To observe what was meant to be. Cool. Okay. And then let's go to second video. Okay. And I'm going to 00:03:50. [Audio: The participant is indicating the lighter and darker lines seen using the ripple tank, using the crests as the darker lines because it is what the learners chose as the assumed idea. A learner is seen and heard saying that it is according to science that the crests are observed as the darker lines with the troughs as the lighter lines. The participant answers the learner by saying that according to science it may actually be the other way around but will prove the phenomenon when they cover the section on the refraction of light.] Okay. So right there you make the learners think.

INTERVIEWEE: Yeah.

INTERVIEWER: Why did you… he… you basically were explaining the… the dark and the light…

INTERVIEWEE: Yeah.

INTERVIEWER: And then the learner was like "how" and that's what science proofs. And you actually went back to him and said "actually if it were up to science, it would be the opposite way".

INTERVIEWEE: Yeah.

INTERVIEWER: Why did you say that?

INTERVIEWEE: Because I didn't want them to think that what they observed is naturally what is exactly happening. So and that because we know that they always do this, when they do, do which is the light, which is the dark, they always assume that because the trough is shallow a bit of water, that the light can get through it much easier. Where if it's a thicker piece of water say on a crest, it has to go through more water, so it naturally becomes darker. That's logically what you would assume, but that's not what happens and they… obviously they followed logic.

INTERVIEWER: Yes.

INTERVIEWEE: And I didn't want them to think just because this case it makes logical sense that that's actually what is happening.

INTERVIEWER: And what I like about what you did there as well, is that you didn't just for the lack of better term fog it off in a sense of ignore him.

INTERVIEWEE: Yeah.

INTERVIEWER: You… you… you did explain and you said "I will explain later" and you didn't get into the depth of it. Did you eventually explain it to the learners?

INTERVIEWEE: Yes. Well we were… we are still doing reflection.

INTERVIEWER: Okay. Okay.

INTERVIEWEE: So when I start with refraction next week then they will draw the diagram and they will have that all explained to them. And we'll bring them back to the ripple tank and we'll say "okay, let's go through this. We did mentioned this briefly, I kind of. You guys said this was the case. Do we still believe this is the case?" And then try and get them to think about it and then we'll prove it using refraction.

INTERVIEWER: Perfect. Okay. Then the last clip which is 00:05:43. [Audio: Learners are seen and heard talking about hypnotism after seeing the circular patterns using the ripple tank and balls attached to the ripple bar] Okay. So even though that learner was talking about hypnotism…

INTERVIEWEE: Yeah.

INTERVIEWER: And you say to them "it had nothing to do with what… what they were doing there"…

INTERVIEWEE: Yeah.

INTERVIEWER: What do you think this scenario was at least showing you? What do you think she was at least doing?

INTERVIEWEE: She was looking at it obviously and she was making the connection between the circular kind of… even though it doesn't spiral, because it's the circular black and white it kind of does look like it's hypnotic and it's drawing them in, which you could also, I suppose, say is hypnotism.

INTERVIEWER: Yeah. And I just think it was also something that you got her mind thinking…

INTERVIEWEE: Yes.

INTERVIEWER: Whether it was the right or wrong thing, she was still observing something…

INTERVIEWEE: Yeah.

INTERVIEWER: Which brought knowledge from elsewhere and… and made them think. I don't know if you agree with that?

INTERVIEWEE: Yeah. It did make her think. Yeah.

INTERVIEWER: Cool. Okay. So… I don't understand my question here. Right. Let's just move on then. So which lesson or sections of the lessons were the learners most engaged when you look at all three of the lessons?

INTERVIEWEE: I think they were… they were probably the most interested to see what's happening with the ripple tanks, however they were… I still think they do focus when we do, do the representations on the board. Because I think they, not necessarily because maybe they want to be, but because I think they see the value in because that's what's going to be in assessments. So I think they do enjoy the ripple tanks but they still do focus quite well when it is a diagram because obviously they see the significance in it. But it wouldn't be to the same extent as during the practicals. They seem to be a lot more engaged with that because it's obviously seeing something that you can't normally see in everyday classes.

INTERVIEWER: So basically you're saying that out of all three, they were more engaged when you're doing some sort of representation…

INTERVIEWEE: Yeah, very much so.

INTERVIEWER: Compared to when they were sitting at their desks.

INTERVIEWEE: Yeah.

INTERVIEWER: Perfect. How did you know your learners were engaged and excited?

INTERVIEWEE: Because they… you can hear it. They talk about it. They tell you. You can see by the way they question, the way that they… instead of getting distracted and talking to their friend about whatever, I don't know whatever they talk about, they were actually talking about what was actually happening. So if they are say again distracted by their friend, they're not getting it… like distracted, they're go on a completely different topic. It's always about… well in this case it was always about what they're actually doing.

INTERVIEWER: Perfect. Which lessons best approached and dealt with learner misconceptions for you and your learners? Or not necessarily which lesson, when… what were you doing that… that was a time that your… your learners understood things or the misconceptions were removed?

INTERVIEWEE: I think when they actually are with the representations. So if they are say using a ripple tank or if they are using say something that they need to actually observe what's going on or even with the diagrams. You can still do it with that, but obviously it's not always so effective. But I think when they actually are seeing what's happening and try to make sense of it in their heads, then they can ask the questions and they can… and also because of the way I think sometimes I did prompt them, they were more able to discover what was going on…

INTERVIEWER: Yes.

INTERVIEWEE: And I was able to see what they were getting, what they were not getting because they were more vocal about it

INTERVIEWER: All right. And then how will you be able to know whether your students understand the concepts you trying to teach or have try to teach? I mean you mentioned now that when they're drawing wavefronts you noticed something.

INTERVIEWEE: Yeah. So when we… when we do, do say practice examples, because obviously they can't do a ripple tank in the exam, so they can't all have their own ripple tanks and use that to set up this phenomenon. So when they do… do the practice examples, I do see how they get it and often they do get the concept, but they might not get the accuracy or like the detail. So if they do reflect, they can tell me the direction that it reflects, but they might not necessarily always get the fact that the angle of incidence is equal to the angle of reflection or whatever the case may be. So they always will draw the wave fronts correct, but it might not be at the right angle, slightly off. But they… they know the general things. I think that's when you do see how there… especially with the representations they do help, but they maybe also have their flaws because there's certain things you can't always show so nicely such as… like angle incidence, angle reflection without making something that is moving like the video or like the wave and making it stationary. So we can analyse it individually.

INTERVIEWER: Perfect. Out of all the concepts looking back, which concept did you find the easiest to teach and why?

INTERVIEWEE: I think… I think wave length is easiest because I think it's quite an easy thing for them to measure once they figure out the difference between the entire wave and a cycle. I think it's quite easy for them, because it is a unit of measurement that's the distance, and they're quite comfortable with working those out. However, I'll also say that I do think they found that interference was also quite easy for them to understand in terms of noticing it. Not necessarily explaining it, but noticing it because there were so many examples of it during the sessions. So I think they do have a good idea how to identify interference. They may be not the greatest idea of being able to explain it, because that they did struggle with a bit. But I think identifying the interference and then determining the wave length is probably what they got the best.

INTERVIEWER: Okay.

INTERVIEWEE: Was easiest to teach.

INTERVIEWER: Nice. Did you make any changes in class that I observed compared to previous years and your previous classes and lesson plans?

INTERVIEWEE: Okay. So as I've already said, we adjusted the way that we approached it, because of the way that we wanted to see if a change of the way our approach it instead of doing all the properties individually, we did them all on one go. We allow them to get familiar with them before going into them. So we did adjust that compared to how we did teach it last year. And otherwise there was a few things that I did take from the training and did incorporate it in. Obviously I couldn't do that last year because I didn't have the training then. So there was a few concepts that I… a few examples, a few ideas that I did take across and I think that that's the… probably the main things. If there's anything else, I don't think it was obvious or at least it doesn't seem like it's obvious now.

INTERVIEWER: Okay. And are there any changes that you would make the next time you teach the same concept?

INTERVIEWEE: I… I agree with the slinky is not great, but at the moment we don't really have like thick enough rope to really do it with the rope, where I think it would might be a nicer way of demonstrating certain things like interference, because for instance the rope say for instance "I need gym". The one that are slightly high above the walling. They make you do that one exercise where you make waves go through. So those could have been… if we had something like that in the class that could be quite nice for them to actually see. And because they've got the weight they can carry that wave without it moving the entire rope as it goes. So…

INTERVIEWER: And you would do the rope upward and downward…

INTERVIEWEE: Yes.

INTERVIEWER: Not along the ground.

INTERVIEWEE: Yes. Yeah. Where friction is obviously in effect. Yeah. So I would try and get rid of the slinky I think. I think the wave length, the wave length, the ripple tank is very… I still think it has its great benefits. So I wouldn't change really too much about the ripple tank unless I see something of use that pops up.

INTERVIEWER: Awesome. Perfect. Awesome.

APPENDIX O: TRANSCRIBED SCRIPT FOR THE VIDEO-STIMULATED RECALL INTERVIEW, TSHUMA

Part 1

INTERVIEWER: Right, it's still the 15th of March. I am with Participant C and we are conducting the video stimulated recall interview. So Participant what this is about is that I show you the observations that I conducted …
INTERVIEWEE: Okay.
INTERVIEWER: In your lessons.
INTERVIEWEE: Okay.
INTERVIEWER: And then I basically… it is to remind you what happened …
INTERVIEWEE: Okay.
INTERVIEWER: And I will then ask you questions.
INTERVIEWEE: Okay.
INTERVIEWER: There are some questions where I'll say to you "do you remember this?"
INTERVIEWEE: Okay.
INTERVIEWER: If you remember it, I don't have to show you.
INTERVIEWEE: Okay.
INTERVIEWER: You can answer.
INTERVIEWEE: Okay.
INTERVIEWER: So we don't then spend too much time going through everything.
INTERVIEWEE: Okay.
INTERVIEWER: But if you don't remember, you say "no, I don't remember".
INTERVIEWEE: Okay.
INTERVIEWER: We will go to the… the clip, I show it to you and then you can answer.
INTERVIEWEE: Okay. That's fine.
INTERVIEWER: Okay.
INTERVIEWEE: Okay.
INTERVIEWER: Right. So what I'm doing is I'm going to go to lesson one …
INTERVIEWEE: Okay.

INTERVIEWER: And I'm just going to skim through the lesson …
INTERVIEWEE: No that's fine.
INTERVIEWER: With no sound. [Audio: Mistaken audio while trying to find the relevant point to start the audio]
INTERVIEWEE: Okay.
INTERVIEWER: So you can just observe. You can just observe yourself, see what happened, remember what happened …
INTERVIEWEE: Okay.
INTERVIEWER: And then I'll ask you the questions. Okay.
INTERVIEWEE: Okay. [Skimmed through Lesson 1]
INTERVIEWER: Okay. So what I observed is that you had already started obviously the teaching of waves.
INTERVIEWEE: Yes.
INTERVIEWER: You had to start the teaching of waves …
INTERVIEWEE: Yes.
INTERVIEWER: Because of the test that was coming up with the learners.
INTERVIEWEE: Yes, yes, yes.
INTERVIEWER: And so when I started observing you had already obviously introduced waves and done a certain amount of work.
INTERVIEWEE: Yes.
INTERVIEWER: Can you explain to me what you did teach the learners while I was not observing.
INTERVIEWEE: Okay. So the first thing I introduced the concept of transverse pulse and then superposition of pulses, destructive and constructive interference that was… and then I also looked at transverse wave. In general, I explained the concept of crest, trough and amplitude and then also the out of phase and in phase points, that are in phase or out- phase. Then also… I ended about the calculations based on what you call speed frequency and also period and then definitions of those keywords.
INTERVIEWER: Lovely. Perfect. Now in this lesson that I observed, you were basically going through a past question paper that you handed out to the learners. You then discussed it with them. You drew a diagram on the board and you gave them another example on the screen, which was projected up onto the screen.

INTERVIEWEE: Yes.

INTERVIEWER: Give me your reasoning as to why you… you did such a lesson?

INTERVIEWEE: It basically on my… my learners considered when it comes to the… their final… the graph to identify some concepts on the graphs, crest trough, wavelength, so then now I think to considered was we normally use test book questions and then I could see with test book questions they were fine. It's not difficult questions. Then I just said "now let me go to the past papers because they will be having from low order to high order questions". So that they can feel that this questions now… they don't… they're not only simple questions. They are graded from high order to low order. So I safely just feel that. Then I think that… that was the main reason.

INTERVIEWER: Awesome. Okay. So now I'm going to 00:02:40 …

INTERVIEWEE: Okay.

INTERVIEWER: And I'm going to play you a clip …

INTERVIEWEE: Okay.

INTERVIEWER: And I want you to observe what you are identifying during this clip.

INTERVIEWEE: Okay. [Audio: The participant was talking about wavelength and that it can be measure using any two points that are in-phase and that it is not just measured from crest to crest and trough to trough]

INTERVIEWER: Okay. So in that clip what were you making the learners aware of?

INTERVIEWEE: I think we're talking about wavelength to make sure that it is not always about being crest to crest they should also look at for points that are in phase was the only definition I think I stressed that it is successive crest and troughs. They always forget that there are points that are in phase is also a wavelength, because I saw the misconception somewhat from some learners.

INTERVIEWER: Brilliant.

INTERVIEWEE: Yes.

INTERVIEWER: Okay. So in… I'm going to go to the clip 00:06:30 …

INTERVIEWEE: Okay.

INTERVIEWER: And I want you to observe what you are doing there as well.

INTERVIEWEE: Okay. [Audio: The participant asks learners to identify the wave that is seen in the question. He asks the learners to raise their hands and he chooses a learner to answer. The participant then asks the learners to explain why it is a transverse wave leaving the learners to answer themselves.]

INTERVIEWER: Okay. So you stand up there and you ask the question. What do you do then? Do you give them the answer or do you make them answer?

INTERVIEWEE: Normal I make them answer or just give them a hint, but basically I wanted… I give the question but if I see that they are confused, I give them a hint. But normally when I give the question, I make them answer or give them a hint.

INTERVIEWER: Okay. And in that clip, you also and a lot through all your lessons in fact, and I have written down …

INTERVIEWEE: Yes, yes, yes.

INTERVIEWER: A number of times …

INTERVIEWEE: Okay.

INTERVIEWER: You say to your learners "explain why".

INTERVIEWEE: Okay.

INTERVIEWER: Give me an explanation". You don't just give the answer and then carry on.

INTERVIEWEE: Yeah.

INTERVIEWER: What is your reasoning for that?

INTERVIEWEE: You know I always tell my learners basically in Grade 10 that physics is not all about memorising, because they can… they like to just to know things and in depth they don't even know. So I like them to relate where, how, why is this happening? Why is so? Because they can just know it's a transverse wave without looking at the diagram, but why is it a transverse wave? They should know the difference between the transverse wave and other kind of wave. So if they explain, they know better. If they just know from the diagram, they cannot do follow up question needed to deduce from the first question.

INTERVIEWER: Perfect. Okay. Now I'm going to 00:08:10 and I also want you to tell me what you were doing here or making the learners aware of.

INTERVIEWEE: Okay. [Audio: The participant indicates to the learners before he even asked the question that they are going to argue about the upcoming question because learners find it challenging. The question is to identify how many waves is seen in the diagram.]

INTERVIEWER: Okay. So what are you identifying here again?

INTERVIEWEE: Yeah I think from my learners I considered they've got a problem when it comes to number of waves then I just talk… we've got how many… because they were doing crest and then for them to identify number of waves, I saw it was a problem. So I was just trying to make sure that they can easily count number of waves, look to check that it's… what can I say… if you are giving it's not… if you are giving the crest, you count your wavelength from one phase, another phase and then if make these an extra half, because it is a half wave. So I could see there's a basically that it was a challenge, even when I was doing initial and [inaudible 00:08:27] topic, they could identify what… we… whether there's a half a wave. So I was trying to consider that one that they should…

INTERVIEWER: Right.

INTERVIEWEE: Know that yes wavelength is from crest to crest yes, but they can also identify that at times there's a and… and… and incomplete wave, if you considered to say half wave.

INTERVIEWER: Brilliant. And then also you do a very similar thing in 00:19:50.

INTERVIEWEE: Okay.

INTERVIEWER: You are… during that clip I can show to you if you do not recall, but again you reiterate to the learners that calculations are problems and they cause problems.

INTERVIEWEE: Yes.

INTERVIEWER: Do you remember telling your learners this?

INTERVIEWEE: Yes. It was… I remember basically when I even when I give them calculation most of them… it's because of their background in maths. So when their calculations, I always try… I always make sure that that very day there's intervention. So when it comes to calculation it's a problem. I know. They look their answers, so I mean everything is left blank and they're not… questions are not answered.

INTERVIEWER: Yes.

INTERVIEWEE: So I always know that when it comes to calculations then that means I have to make sure there's more emphasis and even more intervention, because basically their background in maths is bad. It's unlike when I'm speaking chemistry here and there, but physics because of maths it's a problem.

INTERVIEWER: Okay.

INTERVIEWEE: Yes.

INTERVIEWER: Do you feel in this lesson, that your learners were engaged with you?

INTERVIEWEE: Normally I… I… that's my… I enjoyed what you called teacher learner discussion in class. I just don't like you know chalk talk. The more they're involved, I think they learn more. So I think they were involved and they were excited for the first lesson I think so.

INTERVIEWER: Good. And what representations were you using particularly in this lesson?

INTERVIEWEE: Basically I think… what did I use for past question papers and then projector. That's what I was using basically. Yes.

INTERVIEWER: Perfect. Awesome. And then what I would like you to do is what I observed from you is that and this I might be jumping the gun a bit…

INTERVIEWEE: That's fine.

INTERVIEWER: But it's what I observed in all three lessons…

INTERVIEWEE: Yes.

INTERVIEWER: Is that even though you don't necessarily use too many representations…

INTERVIEWEE: Yes.

INTERVIEWER: You make sure that your learners are always engaged with you.

INTERVIEWEE: Yes.

INTERVIEWER: Making sure that they answer.

INTERVIEWEE: Yes.

INTERVIEWER: You… you chose learners specifically to give answers. Okay. We're just stopping the… the recording at process at the moment.

Part 2

INTERVIEWER: Right. So we are continuing with Participant C's video stimulated recall interview. As I was saying, did you feel that your learners were engaged in that lesson one?

INTERVIEWEE: Yeah. It was pupil centred. So I think they really engaged.

INTERVIEWER: Perfect.

INTERVIEWEE: Yeah.

INTERVIEWER: And if you had to choose out of one of these teaching styles, which one would you say best describes that lesson?

INTERVIEWEE: I think it was more facilitator.

INTERVIEWER: Yes.

INTERVIEWEE: And then let me see this one, okay and dedicator yes. But I discovered it's quite good to introduce with learners. Yes, yes. To delegator ... I think I will… that's what the one.

INTERVIEWER: Perfect.

INTERVIEWEE: Delegator yeah.

INTERVIEWER: Perfect. Delegator.

INTERVIEWEE: Okay.

INTERVIEWER: Lovely. Right. So now what we're going to do is we are going to look at lesson two.

INTERVIEWEE: Okay.

INTERVIEWER: And again I'm going to just skim through it so that you can see what it involved.

INTERVIEWEE: Okay. [Skimmed through lesson 2]

INTERVIEWER: Okay. So in 00:01:30. [Audio: The participant is seen and heard asking the learners to compare a transverse wave and longitudinal wave and what it is they see as being different between the two] Okay. So you ask your learners what do they see. Is that something that you normally ask or is it something that you learned from the training?

INTERVIEWEE: I think yes I normally ask, but I also think learned something from the training, because I normally ask for them to distinguish between… from look at the diagram to seek the differences. So even again from the training I can say I learnt a lot because it was… I learnt some was from the when you busy doing demonstration, I was asked "so what do you see happening there in the… in the ripple tank?". So I think it's also what I applied there from the learning of the training.

INTERVIEWER: Lovely. Now in this lesson, you took a different aspect towards your lesson. You asked two learners to come up who have prepared for the lesson. What was your reasoning for this?
INTERVIEWEE: Right. The day before, the learners… they volunteers just said they want to do a presentation, where they normally know that in science or when you do something, you present you don't forget that concept. So I was like "okay if you guys willing to do that, then it’s fine. Because one other thing I know if you present a topic you won't forget". So that topic is going to be… you will master till the end. Teachers has a way of saying, ''okay it's a different approach of learning" and then also benefitting the same learners that are presenting.
INTERVIEWER: Lovely. So that's… that's what was my next question was that you could tell… well I could observe that the learners were well prepared and it was evident by the fact that they had drawn images and put a poster together and they were even acting like a proper teacher.
INTERVIEWEE: Yes.
INTERVIEWER: They were making learners put up their hands. They were asking learners to get involved.
INTERVIEWEE: Yes.
INTERVIEWER: They were even asking questions and they were giving reasons.
INTERVIEWEE: Yes.
INTERVIEWER: Now my question was going to be to you what was your instruction to them the day before to get them so prepared?
INTERVIEWEE: Yeah, yeah. What I just say first… I just remember for the learners to understand the concept you want to teach, make sure it was something visual. A chart… I emphasise on a chart. That's for you… for them to understand mixture you've got a chart, a learning aid, so that they can understand better because if we going… just going to go and talk with them and then just say they will forget but prepare the charts and that explain using a diagram.
INTERVIEWER: Lovely. [a pause due to the teacher leaving the room]
INTERVIEWER: Okay. So I am now on 00:05:40 and I would like you to observe what is happening in this… in this clip.

INTERVIEWEE: In this clip. Okay. [Audio: The lesson involved incorporating two learners who had made a poster on the idea of longitudinal waves. They also facilitated the answering of questions about longitudinal waves and were in charge of asking the questions as per the textbook and writing the answers down on the board. The two learners did not just ask the question and then write the answer, they also in their own capacity explained the reason as to why the answer was correct.]

INTERVIEWER: Okay. So in that clip, I see that the learners not only give the answers, but they also explain why it is the answer.

INTERVIEWEE: Yes.

INTERVIEWER: What do you think this indicates?

INTERVIEWEE: Say the question again.

INTERVIEWER: Okay.

INTERVIEWEE: Okay.

INTERVIEWER: So I see that the learners …

INTERVIEWEE: Yes.

INTERVIEWER: Not only give the answer that it's a crest …

INTERVIEWEE: Yes.

INTERVIEWER: But they also explain why it is the answer. What does this indicate to you?

INTERVIEWEE: Yes. I think they need to emphasise because as I was to say, I don't want learners just to understand that this is a crest, this is a trough. Why is it a trough? Why is it a crest? And I can help in-depth knowledge of the concept. Because if they just know it's a crest or just they will confuse, crest or trough. So that's why they emphasise why is it, they know that is the lowest point of the wave… that is the peak, the highest point of a wave. So it makes them understand better, because I've seen sometimes the way they swop them to even say that one is the trough, that one is the crest without understanding that crest is the peak, trough is the lowest point.

INTERVIEWER: Okay. And do you think that this learner was able to explain why, if she herself didn't understand?

INTERVIEWEE: I doubt because if she… but she's in terminology of this concept. She understood the concept before.

INTERVIEWER: Perfect. Right. Now at 00:09:00 the learners explain the propagation of waves. You allow them to continue and to explain even though not all of their descriptions were correct.

INTERVIEWEE: Yes.

INTERVIEWER: And then you had decided to come in a bit later. So let's play it and then I'll ask you the questions. [Audio: The two learners with the poster in front of the class are observed trying to explain the propagation of longitudinal waves compared to transverse waves. Even though they stumble along the participant allows them to continue without interrupting them. Only once the two learners have finished their explanation does the participant recap the idea of the propagation of waves for both transverse and longitudinal waves.] Okay. So you can tell that this was mainly a discussion.

INTERVIEWEE: Yes.

INTERVIEWER: But what was the reason for just leaving the learners to begin with?

INTERVIEWEE: Yes, because I could see they had confidence in what they were doing, but I just… so let me just leave it because now I'm going to lessen their confidence. I will intervein provisionally to just at the end let me just correct the misconception. Because I can see now it makes you… it makes me understand that in a way that means yes, that means even if one was teaching to it reflects back on my… on my teaching. Maybe they didn't understand the concept of… of this propagation of disturbance and… and distance covered. So I just say let me… let them continue, then I'll intervene professionally, not to lessen their confidence.

INTERVIEWER: And do you agree after seeing this clip that after such a good discussion…

INTERVIEWEE: Yes.

INTERVIEWER: Eventually you could hear the learners go "ah".

INTERVIEWEE: Yes, they understand now.

INTERVIEWER: Okay.

INTERVIEWEE: Yes.

INTERVIEWER: So do you agree that that meant that they understood the concept?

INTERVIEWEE: They understood yes, the concept yes. Because I could see yes when I say "those who don't understand" since I considered presenters also, that a misconception that means maybe the whole class might have a misconception. So it's better to intervene at the end, they can correct everything holistically.

INTERVIEWER: Lovely. Okay. And then a bit later on they ask a learner a question. And they… we say to the learner "do not use your textbook, rather just explain why".

INTERVIEWEE: Yes.

INTERVIEWER: What is the reason for this?

INTERVIEWEE: Yes, the question again…

INTERVIEWER: Okay. Let's go look at it.

INTERVIEWEE: Okay.

INTERVIEWER: So at 00:11:00. [Audio: The two learners and the class are answering a question from the textbook. The participant is seen and heard to prompt the learners to explain why and not just state what and also to not look down at their textbook]. So there you tell them to not look at their textbook, rather just explain why. What is your reasoning for telling them to not look in front of them and to rather just explain?

INTERVIEWEE: The question was about what? I think I'm missing something here. I just said explain why? Can I see it again?

INTERVIEWER: Yes. Sure.

INTERVIEWEE: I'm still trying to think._Okay. [Audio: The same audio as above repeated for the participant]

INTERVIEWER: So basically you were electing to the learner that you didn't want them just to read the definition from the textbook.

INTERVIEWEE: Yes.

INTERVIEWER: You wanted them to look up and to actually explain what they learnt.

INTERVIEWEE: Yes.

INTERVIEWER: Why did you ask them to do that?

INTERVIEWEE: I guess so with this learners if they just look at the textbook and read, maybe they don't understand because it's… they should tell me the difference between the two by looking at the diagram, looking at the features of the longitude and the transverse to say that why is this one a longitudinal and why this one a transverse wave, because by reading… they can just read it, don't understand the meaning…

INTERVIEWER: Exactly.

INTERVIEWEE: Yes.

INTERVIEWER: Perfect. Then at 00:12:00 the… you start looking at a calculation which is speed equals distance over time. And a learner said to you "speed is velocity".

INTERVIEWEE: Yes. Okay.

INTERVIEWER: Do you recall this?

INTERVIEWEE: Yes, yes.

INTERVIEWER: Okay. So at that point, what did you do?

INTERVIEWEE: I just said "let me just intervene straight because of this misconception is going to kill forward to stay speed is velocity". Yes, it’s fun creating, but I just let me intervene because it's going to be a problem when you come to mechanics, just say speed is velocity. So you should know that yes it's the changing distance over time but that one is a vector, that one is a… is a scalar, so I just wanted to intervene early.

INTERVIEWER: Good. And you intervened because you agree that they're not yet at the point where they would know that.

INTERVIEWEE: Yes.

INTERVIEWER: Good. Okay. Again, what representations were you using in this lesson?

INTERVIEWEE: I think here it was, learning aids, a chart. I'm not sure if I used projector. For basically it was learning aid, a chart and textbook and then demonstration from… I mean presentation from learners.

INTERVIEWER: Yes. Brilliant.

INTERVIEWEE: Yes.

INTERVIEWER: Perfect. Okay. Let's go to lesson three, the last lesson.

INTERVIEWEE: Okay.

INTERVIEWER: Okay. So we just going to quickly go through it again…

INTERVIEWEE: Okay.

INTERVIEWER: Skim through it.

INTERVIEWEE: No problem. [Skimmed through lesson 3]

INTERVIEWER: Okay. So in this lesson we covered basically sound waves. Now at 00:04:50 a learner asked about what a vacuum was…

INTERVIEWEE: Yes.

INTERVIEWER: Once you have written the word vacuum on the board.

INTERVIEWEE: Yes.

INTERVIEWER: What do you think this indicates the learner was doing?

INTERVIEWEE: So in a way I think you know I always thought was we deal with the vacuum from Grade 9, so I… I thought they have prior knowledge of vacuum. So it's really show it that it doesn't know it. So it was a new word… what is a vacuum. So was completely lost to say what is a vacuum? From the way asked you could see that it is completely… it doesn't understand what a vacuum means. So it to make sure explain what it means because it doesn't make sense you write a word, based on prior knowledge, made them do it away. So I'd explain into it.

INTERVIEWER: Good.

INTERVIEWEE: Yeah.

INTERVIEWER: Good. Okay. Then at 00:06:20 you ask one of the learners, who started answering a question…

INTERVIEWEE: Yes.

INTERVIEWER: As to why sound travels faster in a solid compare to a gas or a liquid.

INTERVIEWEE: Yes.

INTERVIEWER: You ask this learner to come to the front.

INTERVIEWEE: Yes.

INTERVIEWER: Why did you do that?

INTERVIEWEE: From the way is I just could see that she really needs to come up front when we started to talk because initially it is just indicated that she wants to present on this topic. So when I was study the topic, just say… say I want to come to you, then now I saw her hand up and her was energetic. So I thought let her best come to the front and explain visually how it's… sound is propagated.

INTERVIEWER: Good.

INTERVIEWEE: Yes.

INTERVIEWER: Perfect. Okay. So at 00:21:00 it is… I'm going to play it from 00:21:00 to 00:23:00, so it's two minutes that you'll be listening.

INTERVIEWEE: Okay.

INTERVIEWER: And I want you to explain to me here what you observe yourself doing.

INTERVIEWEE: Okay.

INTERVIEWER: Okay.

INTERVIEWEE: Okay.

INTERVIEWER: With regards to… okay, let's look at the clip, then I'll ask you the question.

INTERVIEWEE: Okay, no problem [Audio: The participant was observed recapping from the learners Grade 9 knowledge about what factors affect resistance and he spoke about temperature being one.]

INTERVIEWER: Okay. So what did you do there to ensure that the learners remembered?

INTERVIEWEE: So I had to go back to Grade 9 and know that how… why temperature affects the resistance I do link it because they know that one. So I had to explain in detail, so what does temperature do to increase the speed of sound? So I had to link with the prior knowledge of resistance and temperature.

INTERVIEWER: Good. Brilliant. Okay. Then in 00:23:45 there was a different type of question…

INTERVIEWEE: Yes.

INTERVIEWER: That was asked in the textbook. I'm going to go to it and again, I want… I'll then ask you questions on it.

INTERVIEWEE: Okay. [Audio: The participant is reading a question from the textbook which asks the learners to relate the relationship between altitude and temperature. The teacher prompts the learners thinking by breaking down the question by asking the learners to identify the effect of altitude on the temperature and then asking why. He leaves the learners to think about the answer for themselves before discussing the answer]

INTERVIEWER: Okay. So what order thinking do you think this particular question was? What level?

INTERVIEWEE: This was more like I can say high order question because the need to understand the concept of altitude with what would temperature, so basically it was a high order question and it really required some bit of in-depth knowledge of what happens with temperature as you go up and then since we have to explain that temperature, decreases as it go up, then actually have known that now how system temperature effects speed. So it was also based on what… on the relationship of altitude and temperature and then to explain its high order question in short.

INTERVIEWER: Brilliant.

INTERVIEWEE: Yes.

INTERVIEWER: Perfect.

INTERVIEWEE: Yes.

INTERVIEWER: Okay. So in 00:31:00 you use a real life example of athletics day.

INTERVIEWEE: Yes.

INTERVIEWER: In order to describe to them this… the difference in speed between…

INTERVIEWEE: Light.

INTERVIEWER: Light and…

INTERVIEWEE: Sound.

INTERVIEWER: Exactly.

INTERVIEWEE: Yes.

INTERVIEWER: What was your reason to use such an example?

INTERVIEWEE: Right. I could see it… it was a real life one and the way… the initial order I'd seen that I've missed that point of because I should have talked about different speed between sound and light. So when I miss that opportunity for them to be easily engaged, let me just go to the concept of the gun… what do you call… starter gun. And it was for them easier to understand how sound travels slower than what… than light. So I just bring in a real life event because they just came from sports and they… it was going to be easier for them to understand of how sound travels slower than light.

INTERVIEWER: Perfect. And what was the… the aspect you told them to rather look for when the… the starter gun goes off.

INTERVIEWEE: Just look at the smoke when… then tried not the sound. So if the smoke comes, then the starter starts the clock.

INTERVIEWER: Perfect.

INTERVIEWEE: Yes.

INTERVIEWER: Then in the lessons that I observed, you didn't cover super position. Had you covered super position?

INTERVIEWEE: Yes. It was my… I think during the first two lessons I'd covered super position and again it was well understood. So that's why I didn't even have more… to have some intervention in that topic. They really understood the topic, to perfection in fact.

INTERVIEWER: Okay. Good.

INTERVIEWEE: Yes.

INTERVIEWER: Good. Now you have already mentioned it in your previous interview, but please can you reiterate for me the main reason as to why you did not use the ripple tank or why you chose not to use the ripple tank in any of your lessons?

INTERVIEWEE: Yes. I think if only I had time… that on the time factor is the one and then as I were say initially I would have loved to because with my learners, the way they are so keen to learn, it was going to help them a lot. So the only key factor there was time. And then because we need about a double to do the demonstration. So if only I had two periods as I still insist, with the next lessons I think I'll make sure the management knows that I have double periods, certain dates, when I'll be doing my demonstrations, because I normally do them weekends. So it's not applicable. So in… in view if there's time, I will be doing the ripple tank [inaudible 00:22:48].

INTERVIEWER: Okay. So you've… you've just indicated that next year you will mention to management…

INTERVIEWEE: Yes.

INTERVIEWER: That you would like doubles.

INTERVIEWEE: Yes.

INTERVIEWER: So currently you don't have any double lessons with your physical science classes.

INTERVIEWEE: It… yeah, there's only one double lesson and then normally it's on that by then I think since we are using a seven day circle, I think I'd already passed through the double period to… to do there. So it's seven day cycle. There was no I going to teach the waves with… within that period of the seven… seven day cycle.

INTERVIEWER: Okay. No great.

INTERVIEWEE: Yeah.

INTERVIEWER: That's fine. And had you used the ripple tank, how would you have used it?

INTERVIEWEE: Basically as I was saying demonstrate, not say a lot, let the learners identify everything. Then I ask them "what do you think that is?" Always sort of right… I would just… I know it's going to be… I won't explain much. I will just let them observe what's been able to say then learners learn from discovery. So from there they observe, then they tell me what they think that is, then I will start the topic from there. So that is going to be demonstration. They ask learners to identify key point. Then I'll identify from there. I mean demo… I mean start from there.

INTERVIEWER: Perfect.

INTERVIEWEE: Yeah.

INTERVIEWER: Now which lessons out of these three or sections out of these three, did you find that your learners were the most engaged?

INTERVIEWEE: I think it’s lesson two.

INTERVIEWER: And what were you doing?

INTERVIEWEE: I was explaining the presentations, learner teacher presentation, learner discussions, so learners were involved in those demonstration and presentation. So it was learner involvement, teacher explaination and presentations.

INTERVIEWER: Good. Which lesson do you feel, if you… if they all then that's fine, you tell me…

INTERVIEWEE: Yes.

INTERVIEWER: Which at best approached the misconceptions of… of certain topics of waves?

INTERVIEWEE: Just start again.

INTERVIEWER: Okay. So which lessons did you feel that you addressed most of the misconceptions that learners had?

INTERVIEWEE: I think it’s lesson two, if I guess. Yeah. The one where there were a lot of… I'm not sure was it about propagation. Yeah of longitudinal and transverse waves, so I think it’s lesson two. There a lot of misconceptions on lesson two.

INTERVIEWER: Okay. And how will you be able to know whether your students understand the concepts you try to teach?

INTERVIEWEE: Every… after teaching I make sure I assess them. I give them some… some… some work, then from there we revise, then that's where I can easily tell what had they understood through assessment.
INTERVIEWER: Perfect. And out of all the concepts, looking back, which concept did you find the easiest to teach and why?
INTERVIEWEE: With them I think transverse wave [inaudible 00:25:36]. It seems they understood transverse wave or whether they were just keen on the first topic on waves. So transverse waves was the most… there were no misconceptions at all there except for a few…
INTERVIEWER: Okay.
INTERVIEWEE: About out of phase points.
INTERVIEWER: Okay.
INTERVIEWEE: Yeah.
INTERVIEWER: Perfect. Did you make any changes in the class that I observed compared to your previous years and previous lessons?
INTERVIEWEE: I think and here was in a way… we always try to… to… to rush against time here, getting the curriculum but I could have just seen that the best thing that learners understand, is not all about teaching and learners not understand. So that's why to make sure there are demonstrations and then to make sure the learners understand. No matter the time factor, let them understand the concept first through demonstrations and explanations. So as I was saying, in future I think life will be easier to always using the practicals on this topic.
INTERVIEWER: Perfect. So basically the next time you teach this, the thing you would changes to incorporate demonstrations.
INTERVIEWEE: Demonstrations and a lot it is going to help basically. So that means… that I'll work into management and then there will be… there will be willing knowing they've seen it here and yes they have apparatus to be using most of the topics now. Yeah.
INTERVIEWER: Perfect.
INTERVIEWEE: I'll do that.
INTERVIEWER: Thank you. That's great.

APPENDIX P: TRANSCRIBED SCRIPT FOR THE VIDEO-STIMULATED RECALL INTERVIEW, CRAIG

INTERVIEWER: Alright, so again it still the 13th of the third. I am with participant D. And we are now starting the video stimulated recall interview. Okay, so hmm, participant. I am going to be, showing you a few clips.

INTERVIEWEE: Okay.

INTERVIEWER: And then I am going to ask you a question on that clip.

INTERVIEWEE: Okay.

INTERVIEWER: Sometimes I ask you the question first, then I will show you the clip and then you can answer as, as you wish.

INTERVIEWEE: Okay.

INTERVIEWER: Okay, perfect. So I am going to show you, what I am going to do, is I just, I am opening it up here and what I am going to do is I am actually going to move along and you are just...

INTERVIEWEE: Okay.

INTERVIEWER: Going to watch, what you do through the lesson.

INTERVIEWEE: Okay.

INTERVIEWER: Okay?

INTERVIEWEE: Yes.

INTERVIEWER: And then I have got a few questions and then at times I am actually choosing certain times...

INTERVIEWEE: Times. Yes okay.

INTERVIEWER: And then we will recall what happened.

INTERVIEWEE: Okay.

INTERVIEWER: If there is ever a question that you say to me, no I don't remember doing that. We will go find it.

INTERVIEWEE: Yes.

INTERVIEWER: We will look at it and then you can recall, okay. Cool. So let's have a look at this. [Skimmed through clip- lesson 1] Okay, so that is pretty much what happened in the lesson.

INTERVIEWEE: Yes.

INTERVIEWER: Okay, so looking back on that lesson clip. What did that lesson mainly consist of for you, when you observe that?

INTERVIEWEE: What did that?

INTERVIEWER: The lesson consists of.

INTERVIEWEE: Okay.

INTERVIEWER: So basically, what did you see yourself doing in this lesson?

INTERVIEWEE: In that prior lesson I was introducing pulses into waves and then I was, it was just being the definitions of all the terms which were going to be explained to me during the, the topic of waves.

INTERVIEWER: Perfect.

INTERVIEWEE: Yes.

INTERVIEWER: And in this lesson, what representations were you using mainly when you look at this lesson?

INTERVIEWEE: Hmm, like on that, in that lesson I was just mainly using the board, writing the few notes for the learners and asking them questions. The learner also drawing the graphs and showing them, pulse length and all that stuff from the graphs.

INTERVIEWER: Good.

INTERVIEWEE: Yes.

INTERVIEWER: And in this particular lesson, I noticed that you were very reliant on your textbook. What was the reason for that?

INTERVIEWEE: The reason for that is like hmm, in the textbook, that is where I was checking which terms we normally use when explaining those terms to the, to the learners. That was to the main reason I was checking the textbook.

INTERVIEWER: Good, now I am going to play a clip, which is a 22 minutes and 24 seconds.

INTERVIEWEE: Yes.

INTERVIEWER: In this clip, and you remember I asked the meaning of one of the words used in the definitions that you put on the board.

INTERVIEWEE: Yes.

INTERVIEWER: Which was the word succession.

INTERVIEWEE: Succession yes.

INTERVIEWER: And you mentioned whether they had to go back to the English class.

INTERVIEWEE: Yes.

INTERVIEWER: Does this often happen in your class where learners are battling with the words that you use? Now do you recall it happening...

INTERVIEWEE: Yes.
INTERVIEWER: Or do you want to go back...
INTERVIEWEE: Ja, ja. I remember, when I was saying succession, more like I was trying, when I was commenting about, ja, English. Hmm, normally it happens in my, in my classes that I, you find out the learners, they are, are being affected in terms by their language barrier. Their English at times is very, it is a bit tricky to them. You also find the [indistinct 00:04:13] when they are in the exams. When they are answering questions. They will answer the other way. Only to realise that they didn't understand the words which were used in the, you know in the question. So that is when you heard me, laughing and saying it is English, which is killing you.
INTERVIEWER: Brilliant, because that is my next question.
INTERVIEWEE: Yes?
INTERVIEWER: Is do you find in your class that English is a barrier to better understanding the subject and you have answered it.
INTERVIEWEE: Ja, English, English is quite the barrier and at times, at times you have to check the words which you use, to simplify them. Then hmm, normally which, normally in Physical Sciences, remember we have to use the exam guideline. But some of them, words which are used in the exam guideline, the learners don't understand that. So you go back to simple English, then take them to the words which are being used...
INTERVIEWER: Brilliant.
INTERVIEWEE: In there.
INTERVIEWER: And do you think that the, this barrier language barrier, has got something to do with the misconceptions that your learners have in class?
INTERVIEWEE: Yes, in times that is, that is the thing, that most of the misconceptions is because of the language barrier. It is because they don't understand what is, what would be the meaning. So at the end they will have this other conceptions, which are different from the actual what was the, or what will be explaining. Ja.
INTERVIEWER: Good. Okay now again. When I go through this clip, at hmm basically from the beginning. Look at your learners and maybe I will put it at 13 minutes, 46 for example.
INTERVIEWEE: Yes? [Audio: The visual shows the learners sitting at their desks not very engaged even when the teacher was teaching. The teacher does ask for a

meaning of the definition of pulses and amplitude and allows the learners to answer before giving the answer].

INTERVIEWER: Okay, so from that clip.

INTERVIEWEE: Yes?

INTERVIEWER: Do you think when you compare it to the lesson where we were using the apparatus and I will ask you questions on that. Were your lessons, your learners very engaged in this lesson?

INTERVIEWEE: Right, in this lesson they were not that engaged, surely one or two who had participating. And ja, this normally, this normally happens, especially when you are introducing something new to them, a new topic to them. And some of them will be puzzled on what is actually, he is saying or what is actually happening.

INTERVIEWER: Okay good.

INTERVIEWEE: Ja.

INTERVIEWER: And the representation that you mainly focused or used on in this lesson, was a text book and I see that the learners have a text book in front of them.

INTERVIEWEE: Yes.

INTERVIEWER: Now when you were asking them in this particular clip, what is the amplitude.

INTERVIEWEE: Yes.

INTERVIEWER: It was nice to see that one of the learners didn't read it from the text book.

INTERVIEWEE: Yes.

INTERVIEWER: Whereas others were just reading it from the text book.

INTERVIEWEE: Yes.

INTERVIEWER: So do you believe that mainly, having the text book in front the learners, is a positive or a negative thing?

INTERVIEWEE: Ja normally, to me it is either way. Especially when you, when you are teaching. For them to have it in front of them. Because in this case when I am asking definitions. Normally they will rush to go and check what is the meaning of the, of the definition. But in some circumstances, it will be very important for them to have the text books in front of them.

INTERVIEWER: Perfect.

INTERVIEWEE: Yes.

INTERVIEWER: Okay. So now we are going to move to lesson 2. And again, I am just going skim through it, just to remind you. [Skimmed through clip- lesson 2]

INTERVIEWER: Okay, so in this lesson, what did you observe yourself teaching?

INTERVIEWEE: In that lesson I was teaching, so it was basically the, the superposition principle, introducing interference. Destructive and constructive interference.

INTERVIEWER: Perfect, now what I find interesting in your lesson.

INTERVIEWEE: Yes?

INTERVIEWER: Is and remember there is no right or wrong.

INTERVIEWEE: Yes.

INTERVIEWER: So I just find it interesting.

INTERVIEWEE: Yes?

INTERVIEWER: That you introduced super position which is constructive and destructive interference.

INTERVIEWEE: Yes?

INTERVIEWER: Straight after doing the definition of amplitude and pulse.

INTERVIEWEE: Yes?

INTERVIEWER: And it was done before introducing frequency and wavelengths. What is your reasoning and thinking behind introducing super position now?

INTERVIEWEE: Alright I always, to me super position is more to do with the, with the amplitude and the pulse. So ja, as soon as they know what is a amplitude, then I wanted them to see how this, the amplitude interact when two pulses approach each other or when they in-phase.

INTERVIEWER: Lovely and...

INTERVIEWEE: yes.

INTERVIEWER: That and I find that very interesting, because teachers do teach super position using pulses, and amplitude, and the fact that you linked it straight after their definitions.

INTERVIEWEE: Yes.

INTERVIEWER: Is a different way of looking at it.

INTERVIEWEE: Ja. But that is how I, I saw it easier for the learners to understand. That after knowing the amplitude, after knowing the pulse, so how do they interact. How is the interaction between the waves, before I go to the wavelength and...

INTERVIEWER: Perfect.

INTERVIEWEE: And the frequency.

INTERVIEWER: Okay, so now I am going to the next clip, which is at 01:30. Through to 02:14. And I want you to observe what are you doing in this clip. Okay?
INTERVIEWEE: Okay [Audio: Incorrect clip]
INTERVIEWER: Sorry, it is actually the second clip of Lesson 2.
INTERVIEWEE: Okay.
INTERVIEWER: At 01:30. [Audio: The teacher had taught superposition and asked learners if they had any questions. A learner asked if it was possible for it to happen if there was more than 1 pulse. The teacher explained that it was but for Grade 10 level, we look at the principle using 1 pulse but the same principle applies if there is three or four pulses]
INTERVIEWER: Okay, so what, what did you, what did you see yourself doing there?
INTERVIEWEE: Hmm, on that instance, I was trying to explain the destructive and hmm, the constructive interference. The cancelling in the building, that if they are on one side, they would have the building, even if they meet five of them in one direction. It would take them as positive. And then in the other direction, they would take the negative. So I was trying to put a point that it does not mean I, that it is only two waves. There may be three, there may be four. But if they meet at the same place, at the same time, and they are in one direction, you are adding up the, the amplitudes. Then they are in the other direction is to be in the negative. So that is how we come up with it.
INTERVIEWER: Lovely, because I don't know if you heard, but before you started answering the learner actually asked you hmm, what happens if there is more than one pulse.
INTERVIEWEE: One pulse yes.
INTERVIEWER: Yes.
INTERVIEWEE: Yes. the learner asked it, I remember the learner asking the same question ja.
INTERVIEWER: Yes, okay, so you happy with the fact that the learner asked you the question and you were trying just analyse and help the learner re-understand.
INTERVIEWEE: Yes, I was quite, I was quite happy about the question. That at least he has realised that this no, this is happening between two pulses. What if there are more, what is going to happen, what is really going to happen if there are more than one.

INTERVIEWER: Good.

INTERVIEWEE: More than two sorry.

INTERVIEWER: Good, yeah.

INTERVIEWEE: Yes.

INTERVIEWER: Perfect, okay so, when we look at lesson 1 and 2 where you have mainly been doing the definitions hmm and when you have been doing destructive and constructive interference. I am going to read to you hmm, the, well not necessarily read. You can actually read yourself again the four learning or teaching styles.

INTERVIEWEE: Yes.

INTERVIEWER: And looking only at these two lessons, tell me what teaching style you believe this was based upon?

INTERVIEWEE: Okay, hmm, the first one is telling/lecture, the second one demonstration. The third one is hybrid/blended, learner facilitator and delegator. I think here I was more of a doing facilitation...

INTERVIEWER: Okay, and what, what did a facilitator do?

INTERVIEWEE: Initiate students. Self learning and it helps learner to develop critical thinking. Allows learners to ask questions and find own answers through exploration.

INTERVIEWER: Okay.

INTERVIEWEE: Yes.

INTERVIEWER: Now do you feel that this was for this lesson or do you feel that was more for your lesson during the ripple tank?

INTERVIEWEE: I think hmm, both lesson is supposed to be, to be like that. where you try to trigger the thinking from the learners so that you get their own ideas and they think on what is happening. And that way it will stick in their heads. Especially if they go wrong and you correct them. It will be easier for them to remember.

INTERVIEWER: But do you think this lesson was, was that?

INTERVIEWEE: Which one, this lesson?

INTERVIEWER: This lesson?

INTERVIEWEE: Ja, like...

INTERVIEWER: When you were writing the definitions on the board?

INTERVIEWEE: When I was writing the definitions on the board, it was more of a lecture. It was more of a lecture in then telling them there, the definitions and stuff.

Then when I was doing super positioning, initially I did, it was the lecture thing, then at the end it was facilitation, where I asking the learners, letting them ask questions and give their ideas for what was happening.

INTERVIEWER: Brilliant.

INTERVIEWEE: Yes.

INTERVIEWER: Perfect. Lovely. And right, so let's move on now to the third and fourth lesson, which was a double. Okay, so when we look at this lesson, this was the lesson where you chose to do or use the ripple tank.

INTERVIEWEE: Yes.

INTERVIEWER: Okay, so was it your first time using the ripple tank in your grade 10's with the lesson?

INTERVIEWEE: It was my first time. It was my first time after the, after the training, that training. It was my first time to, to use it in the class.

INTERVIEWER: Perfect.

INTERVIEWEE: Ja.

INTERVIEWER: And even in your teaching years?

INTERVIEWEE: Even in my teaching years, it was my first time, to use the ripple tank.

INTERVIEWER: Good, okay, so again I am just going briefly go through it.

INTERVIEWEE: Yes.

INTERVIEWER: Okay, I want you to observe what the learners are doing.

INTERVIEWEE: Yes. [Audio: Skimmed through Lesson 3]

INTERVIEWER: Okay, so in minute 5 minutes and 2 seconds, you can instantly see learners standing or starting to congregate around the apparatus.

INTERVIEWEE: Yes.

INTERVIEWER: What do you think this indicates?

INTERVIEWEE: It indicates that there was this excitement of, wanting to have this hands on, because those learners, actually they were saying, say I, can we help you set it up this thing. Just show us how to set it up and why. We will help you and we also want to, to be part of the setting up and those things. Which means there was an excitement, there was this thing and then they wanted to really see what was going to happen.

INTERVIEWER: Lovely.

INTERVIEWEE: Yes.

INTERVIEWER: Perfect. Okay, now I am going to show you a three-minute clip. It is 11 minutes 10 seconds. Okay, hmm, let's watch it and then I will ask you questions.

INTERVIEWEE: Okay. [Audio: The participant is seen using the ripple tank and asking his learners what do they see. And that he doesn't want them to tell him what they think but rather to tell him what they see. He reiterates and asks them again 'what do they see here']

INTERVIEWER: Okay, so in the beginning or through this clip. You hear yourself saying to your learners what do you see, what do you observe? Is this a technique that you learnt from the training?

INTERVIEWEE: Yes, it is a technique which I learnt from the training. But initially you don't have to tell the learners what is happening. Let them think and then try to come up with ideas of what is happening and that way, they are building up their confidence, they are building up everything in their…

INTERVIEWER: Brilliant.

INTERVIEWEE: themselves.

INTERVIEWER: And then also in this clip, you hear yourself teaching the learners that the hmm, crest are the bright lines and the trough are the dark lines. You said something you have taught before or is it again something you learned from the training?

INTERVIEWEE: It is something which I learned from the training. That is something which I, some information which I gained from the training. Ja.

INTERVIEWER: Perfect. Then also near the end of the clip, you hear yourself explaining and demonstrating the relationship between the wavelengths and the frequency, by changing the speed...

INTERVIEWEE: By changing the speed yes.

INTERVIEWER: Do you think it was important for learners to see this?

INTERVIEWEE: It was very important, because that relationship we always use it and it is a very important relationship. So they should, they were supposed to see, that if we increase the speed, what is going to happen there, with the wavelength through the lines which were on the paper. Then I, if reduce was going to happen.

INTERVIEWER: Good.

INTERVIEWEE: It was very, it was very, very important.

INTERVIEWER: And do you agree that that learner over there actually picked it up?

INTERVIEWEE: Yes, he picked it up. He picked it up. That learner he picked it up.

INTERVIEWER: Good.

INTERVIEWEE: Ja.

INTERVIEWER: Perfect. But now I am going to the second clip of this lesson. Alright, and then I am going to 2 minutes 49. [Audio: One can see and hear learners engaging with the teacher and asking questions to get clarification about wavelength and diffraction. The teacher answers the learners]

INTERVIEWER: Okay, so in this clip.

INTERVIEWEE: Yes?

INTERVIEWER: You can, you can see that there are learners that start to ask questions.

INTERVIEWEE: Yes.

INTERVIEWER: Which, do you believe they were asking questions in lesson 1 and 2?

INTERVIEWEE: No in lesson 1 and 2 they were not asking questions that might, it was only three, two three guys who were asking questions. But this time because there were some demonstration, you could get a lot of questions coming from the learners. Because they could see what was happening and also some of the, some of them, were are amazed to see how, so this is what is happening which was quite, quite good.

INTERVIEWER: Good.

INTERVIEWEE: Yes.

INTERVIEWER: Good and you could hear that?

INTERVIEWEE: Yes.

INTERVIEWER: Because they were going oh...

INTERVIEWEE: Oh, hmm.

INTERVIEWER: So eventually they were trying to understand...

INTERVIEWEE: Trying to understand yes.

INTERVIEWER: Brilliant. And again, this particular learner.

INTERVIEWEE: Yes.

INTERVIEWER: He started, he was really interested.

INTERVIEWEE: Yes.

INTERVIEWER: And he even started using words like arc and he asked you questions what would happen, what is an example of real-life situation...

INTERVIEWEE: Yes.
INTERVIEWER: Where there is barriers involved.
INTERVIEWEE: Yes, yes.
INTERVIEWER: Now do you think he would ask, is he normally like this, would he ask questions like this if there was no apparatus?
INTERVIEWEE: He was not going to ask questions like this, because here it was triggered by what he was seeing in that ripple tank. That should trigger him to think of, ja a lot of questions to ask. Which was, which was good anyway. Because it brought this, this thing in him to ask the very relevant questions.
INTERVIEWER: Good.
INTERVIEWEE: Yes.
INTERVIEWER: Okay. Now if I skim very briefly through this lesson, observe what are you doing during the lesson... [Audio: Skimmed through the second half of Lesson 3]
INTERVIEWEE: Yes.
INTERVIEWER: Okay, so in the beginning of this lesson, you demonstrated wavelengths and frequency.
INTERVIEWEE: Yes.
INTERVIEWER: You then demonstrate super position.
INTERVIEWEE: Yes?
INTERVIEWER: And then you demonstrated diffraction.
INTERVIEWEE: Yes.
INTERVIEWER: Now explain to me why you decided to demonstrate diffraction in Grade 10?
INTERVIEWEE: The reason why, I demonstrated diffraction to them, is because I know it is, it is a concept which comes from what they are doing now, which comes in. Although it is coming in Grade 11. But I just got a chance for them to, to open their minds to see what other situations which can happen. What are the other characteristics of waves, which we will be doing next year.
INTERVIEWER: Perfect. Okay and then hmm, very briefly, at 5 minutes, 17. [Audio: The bell is heard ringing but despite it being the end of the lesson, learners are seen to continue asking questions and they start to congregate around the apparatus, pointing at the apparatus to ask further questions about diffraction to get clarification on the idea]

INTERVIEWER: Okay so the bell had already rung.

INTERVIEWEE: Yes.

INTERVIEWER: And learners were congregating again around the apparatus.

INTERVIEWEE: Yes.

INTERVIEWER: And asking you questions.

INTERVIEWEE: Questions yes.

INTERVIEWER: What do you think this indicates?

INTERVIEWEE: It indicates the interest which was there, which was caused by the apparatus. Which was caused by seeing what, what was actually happening. And everyone wanted, everyone had questions. They wanted to know a lot of things which had happened, which do not normally happen when I am teaching this topic. Without using the apparatus or any demonstrations like this. When we are only using the, you see the simulations and stuff. The learners don't ask as many questions as I got this time around.

INTERVIEWER: Good now in general, do you feel you should practise again before you use the ripple tank again? Or do you think the training was enough?

INTERVIEWEE: Ja, the training was, was enough, because I got a lot from the training. And remember, I have just, after the training, when I use it, this, on this day, to me it was just a [inaudible 00:31:43], just getting from what happened during the training. So the training was so effective.

INTERVIEWER: Good.

INTERVIEWEE: The training was so effective.

INTERVIEWER: Okay, let us go the last lesson.

INTERVIEWER: Right, if I skim through this, okay from the beginning. [Skimmed through clip- lesson 4]

INTERVIEWEE: Yes.

INTERVIEWER: This part, the beginning part of this clip. You were teaching super position again...

INTERVIEWEE: Yes.

INTERVIEWER: At the beginning of this, of this lesson.

INTERVIEWEE: Yes.

INTERVIEWER: And I see how you switched off the lights and you indicated to the learners where it is best to see the phenomenon...

INTERVIEWEE: Yes.

INTERVIEWER: This is also something that I was trained or taught to you during the training? Is that so or did you do this previously?

INTERVIEWEE: This was, when I was trying to show them super positioning, it didn't come out because the lights were on and that period, the previous period, it was about to go to the end. Then I when they, when we started this period, I switched off the light, because I got this from the training. During training when we were doing the super positioning. It was very clear to see the, when the lights were, were off and also the direction where you can see actually it was through the, the training.

INTERVIEWER: Correct.

INTERVIEWEE: That is why the training, that is where I got it from the training.

INTERVIEWER: Okay.

INTERVIEWEE: Yes.

INTERVIEWER: Because as you say at the end of the, the third lesson, the first part of the double.

INTERVIEWEE: Yes.

INTERVIEWER: You did show it, but you say you didn't see it too well...

INTERVIEWEE: Yes.

INTERVIEWER: So you did it again.

INTERVIEWEE: Yes.

INTERVIEWER: And switched off the lights.

INTERVIEWEE: It was not clear.

INTERVIEWER: Brilliant.

INTERVIEWEE: And when there was no light, it was very, very clear.

INTERVIEWER: Good, okay and then at 2 minutes 10 seconds. [Audio: The teacher was indicating, using the ripple tank and two circular waves, areas where constructive and destructive interference where being seen. A learner is heard asking the teacher to repeat what he has just said in order to understand what she should be seeing at the areas of destructive interference. The teacher also suggests to the learners where it is best to see the phenomenon- which is in front of the tank facing it head on]

INTERVIEWER: Okay, during this clip a learner was confused about what they were seeing. How did you address this?

INTERVIEWEE: Right I, during this, this demonstration, there was a problem of they didn't understand the constructive and the destructive interference. So I was just trying, I was trying to show them that where there is light, because there was lines which were there. Where there was light, that is where they used constructive interference and where there was a darker line, it was then destructive interference. So I was just trying show them, that is why I was telling them to go to the one side where they could see what was actually happening.

INTERVIEWER: Okay.

INTERVIEWEE: What was actually happening.

INTERVIEWER: Okay, let's go to 18 minutes. [Audio: The teacher was explaining amplitude and making sure that the learners were aware that amplitude is measured from the rest position and not from the trough to the crest. He warned the learners that some of them will make that very mistake when asked to calculate the amplitude]

INTERVIEWER: Okay what did you observe yourself doing there?

INTERVIEWEE: Hmm, that, that is the moment I was trying to explain to them where amplitude comes from and from the rest positioning and going to the crest or going to the trough. And from my experience I was telling them that I would see some people or being saying the amplitude is from there. The trough to the crest.

INTERVIEWER: Good.

INTERVIEWEE: And during this, at the end in the test that they wrote, we had some people were, who did the same thing. And we were laughing at them yesterday.

INTERVIEWER: Oh good, you see.

INTERVIEWEE: Ja, because I was telling them, I told you, that are some people are going calculate, they are not going to take it from the rest position, they will take it from the trough to the crest.

INTERVIEWER: Good.

INTERVIEWEE: Yes.

INTERVIEWER: So basically you are identifying misconception.

INTERVIEWEE: Yes, the misconception of an amplitude.

INTERVIEWER: Good, okay, so now in general, considering this whole double, how do you address learners, learning difficulties, if at all, during these lessons?

INTERVIEWEE: During those lessons, like I, the difficulties you know, learners normally face is, like when you are talking about hmm wavelengths and frequency. The relationship, or able to demonstrate it during the, using the ripple tank. You see when I was increasing the speed and reducing the speed, it turned out well, the constructive, destructive interference, I was able to show them and also the problem is, talking now about the amplitude. Where do you measure amplitude, when it is

from the rest position? All those misconceptions we try to, to cover them up.
INTERVIEWER: Brilliant. Did your learners enjoy the double lesson and what were the indicators if they did or didn't?
INTERVIEWEE: Like they enjoyed it quite a lot and they were saying we should go and do more of these using a number of apparatus to demonstrate a lot of things, I think they said using of simulations. And they looked so interested in having more of the practical work using, these potential apparatuses.
INTERVIEWER: Good, do you think that the learners learnt what you intended them to learn in this lesson using the ripple tank?
INTERVIEWEE: Yes, I, it came out quite well because they understood. They understood why, the concept, most of the concept which we, we demonstrated on the ripple tank.
INTERVIEWER: And like you have already said when you marked your tests.
INTERVIEWEE: When I marked my tests, they, I realised that there are this learners, they, they were picking from the, that lesson which we did for using the apparatus, that was really important.
INTERVIEWER: Brilliant. Now looking at these lessons. The lesson 3 and lesson 4 using the ripple tank.
INTERVIEWEE: Yes?
INTERVIEWER: And you look at these teaching styles.
INTERVIEWEE: Yes?
INTERVIEWER: With lesson 1 and 2 you spoke the main being hmm, Lecture. What would you indicate these lessons were like?
INTERVIEWEE: These ones, it was more of demonstration. Because we demonstrating using the ripple tank and more facilitating also. It was more for demonstration and facilitating because we are interacting with the kids. They were asking, I was asking them what they, they are seeing, what they think is happening.
INTERVIEWER: Perfect.
INTERVIEWEE: Yes.
INTERVIEWER: Would you have felt as comfortable using the ripple tank had you not had training on the apparatus?
INTERVIEWEE: No, I was not going to be comfortable, because even checking the manual, I later realise no, if there was no training I was not going to be able to use the ripple tank. So the training was, is very essential. If you get apparatus, I think the

person, people who are going to use it, there should be some training of some sort. Because when I looked at the manual, it is, eish, after, after the training, I realised that nothing was going to come out.

INTERVIEWER: So you, and you just highlighted a very good point. It is even though a manual was supplied.

INTERVIEWEE: Yes.

INTERVIEWER: It is confusing.

INTERVIEWEE: It is confusing. You know, you can't actually pick what is happening. It is easier, for me it was easy, because there was training, there was being guided, I was seeing everything being done. So it was for me, it was easy.

INTERVIEWER: Good.

INTERVIEWEE: Yes.

INTERVIEWER: Now I watched at the end, how you took the battery out of the ripple tank controller, once you had demonstrated this to, to your learners.

INTERVIEWEE: Yes.

INTERVIEWER: Again, was it something that you learned from the training?

INTERVIEWEE: Yes, I learned it from the training, because during training when we finished, that was the first thing which we did so that we preserve the battery for…. So it was supposed to be out of the controller as quickly as possible.

INTERVIEWER: Good.

INTERVIEWEE: Yes.

INTERVIEWER: Okay, now out of all these lessons, which lessons do you think the learners were most engaged?

INTERVIEWEE: It was the one which we were using the ripple tank. I think it was lesson 3. 3 the one for the, for the double. It was one, they were engaged because we talked a lot, and they were asking a lot of questions and we were telling me what they were seeing, correcting them and getting a lot of ideas from, also from them.

INTERVIEWER: Good.

INTERVIEWEE: Yes.

INTERVIEWER: And which lesson, best approached and dealt with learner misconceptions?

INTERVIEWEE: It is this one, which we used the ripple tank. Because they, a lot of the misconceptions we were able to deal with them, especially the frequency and wavelength. The diffraction, all those misconceptions. Most of them we dealt with.

They realised a lot of things from there...

INTERVIEWER: Good.

INTERVIEWEE: From the demonstration ja.

INTERVIEWER: How will you be able to know whether your students understand the concepts, you tried to teach them?

INTERVIEWEE: Normally for you to know how would they understand the concepts, is when they write their tests. Then you get a feeling that what I was teaching them, what I was trying to explain, they understood it. Like what I was saying now, that some of the answers which I got, it, I realise that no this guys, they really really understood it from the use of that ripple tank.

INTERVIEWER: Lovely.

INTERVIEWEE: Yes.

INTERVIEWER: Out of all the concepts, looking back, which concept did you find the easiest to teach and why?

INTERVIEWEE: The easiest one to teach was the one for, the relationship between frequency and hmm, the wavelength. Because it was, actually it is easy to demonstrate, because you are just increasing the speed. Then the lines will go far apart when I reduce and come back together. So it was very easy to and they will, all of them, they all realise what was happening. And that was very easy too.

INTERVIEWER: Good.

INTERVIEWEE: Ja.

INTERVIEWER: Did you make any changes in the class that I observed compared to your previous years and other classes or lesson plans?

INTERVIEWEE: Ja, there were some changes. Because like now because I was now demonstrating using a ripple tank. There was a little bit of changes. Because we normally use some simulations and stuff. So I do readjust. Because I was more so excited with the ripple tank, because it was taking, making my life a little bit, a bit easy in explaining some of the stuff.

INTERVIEWER: Good. Do you believe what you planned out to achieved was achieved when actually coming to carry out the lesson or did you deviate from your planned lesson plan?

INTERVIEWEE: Well, actually what I wanted to achieve, I think it was achieved during that time. That lesson, because the concepts what I wanted the learners to grasp, I think they got them...

INTERVIEWER: And what lesson are you referring to now when you say this lesson?

INTERVIEWEE: The one which I was using the ripple tank. The one which I was demonstrating. It helped a lot because the learners understood. They, because they were involved and it was more practical so they realised what was actually happening. You know seeing is, it makes things very, very easy.

INTERVIEWER: Good.

INTERVIEWEE: To understand ja.

INTERVIEWER: Okay and last question. What changes would you make the next time you teach waves?

INTERVIEWEE: I will...

INTERVIEWER: If, there doesn't have to be anything. But if you think back, what would, if there are any changes, what would they be?

INTERVIEWEE: Hmm, the changes which, which I might make before I even use the ripple tank, I have to also introduce the wave on its own. Showing the crest and the trough and the rest position before doing demonstration on the, on the ripple tank. I think that way they will understand even more when you are doing the demonstrations.

INTERVIEWER: Perfect, okay, thank you very much.

INTERVIEWEE: Okay, thanks very much.

APPENDIX Q: TRANSCRIBED SCRIPT FOR THE SEMI-STRUCTURED POST-INTERVIEW, JESSICA

INTERVIEWER: Okay, so today is the 14th of March. I am with Participant A and we are going to commence with the post semi-structured interview questions, thank you. Today is basically going to be split into 2. We're going to do your post semi-structured interview and then we'll pause and then we're going to do the video stimulated recall interview. Ok, Right, so the first few set questions are, primarily, on the training. How you felt about the training. So the first question is, were the explanations on the equipment and the activities clear and helpful to you?
INTERVIEWEE: I think the explanations in setting up the equipment and how you use it was very clear. What was the other part of the question?
INTERVIEWER: Just in general, was the training clear...
INTERVIEWEE: Yes
INTERVIEWER: Did you, you know, did you enjoy it?
INTERVIEWEE: Yes, I did. I thought it was useful. I thought it was beneficial and the way that it was structured for us to set it up seems to be quite easy, cause we've been able to do it, so that was, obviously, clear as well.
INTERVIEWER: Great, and were your perceptions changed on that ripple tank?
INTERVIEWEE: Yes, originally, I was quite opposed to using it and this time around teaching with it I've used it a lot more, so it did change that because of the fact that there is a lot of mistakes in the old one, but now we have corrected it with the newer design
INTERVIEWER: Great, perfect. In what ways did the in-service training effect your attitude towards the practical work for waves?
INTERVIEWEE: It showed me that there was a little bit more that I could do with the ripple tank, than what I originally thought I could do, so it did open my eyes to a new, well, few different ways of doing it. Where before, I wouldn't have done it that way, so it did open with that, but in our way we do approach it, we are quite practical focused section anyway, so it did just make it even more so.
INTERVIEWER: Brilliant. In what ways did the in-service training effect your confidence on that particular piece of apparatus?
INTERVIEWEE: It did give me a bit more confidence in using it and making sure I can get the best that I can out of it and I do think that it did help. However,

sometimes, it also made me feel a little bit insecure, in the fact that I didn't know everything and I was still teaching humans while not knowing everything, that, maybe I could have.

INTERVIEWER: Brilliant, so that's basically the next question, is that, often, we believe teachers should know everything, so, and that's the point of training and that then leads to the next question is, in what ways did the in-service training effect your science content knowledge on the topic.

INTERVIEWEE: I think it did open up some things that I hadn't considered, hadn't thought about and, for me, that was very beneficial, so it did broaden that and, yes.

INTERVIEWER: Are there any specific examples that you can remember through the training, what, in terms of content knowledge that you gain from it?

INTERVIEWEE: The way that it was trained was a nice way to approach to the different properties . Where usually we just look at each individual property, by itself. The way that it was discussed in the training say with the interference and the reflection being at the same time. It's, I found it a lot easier to introduce them and get them used to the different properties, all in one go. Where before it wasn't done like that, so I felt that, that, especially with teaching the properties, using the ripple tank, was really nice to be able to, kind of, give them all exposure to all the different properties, where, before, we didn't do that, all in one shot.

INTERVIEWER: Perfect. Did you benefit from the in-service training and what did you like best about the training?

INTERVIEWEE: I did benefit from the in-service training and I liked, best, that it was calm, like, it wasn't, like, pressured. It wasn't, like, sometimes, when you go to training, people don't even like, it seems like they go so quickly through the stuff. Where here, it's like we could talk, we could ask questions. We could, it was quite interactive, so I felt that that was quite nice about the training because it was a lot more relaxed and a lot more comfortable than, sometimes, the other trainings you go to, which might be more distant.

INTERVIEWER: Perfect, and a lot of teachers have, in the past, mentioned how they don't really like training because they feel so insecure and because it is not really a comfortable platform to show the things that they don't understand, so were you comfortable in this training to ask your questions.

INTERVIEWEE: I felt that, that was appropriate, yes.

INTERVIEWER: Perfect.

INTERVIEWEE: Yes.

INTERVIEWER: Awesome. Did your perception of the ripple tank change after the training? We have already addressed this.

INTERVIEWEE: Okay.

INTERVIEWER: Okay, we're about to be interrupted.

INTERVIEWEE: Okay, sorry.

INTERVIEWER: Okay, we're commencing the post semi-structured interview with Participant A. So as I've already asked. Did your perceptions on the ripple tank change after the training and you have already, briefly, discussed that, but I know, particularly, yourself, when you were doing the training, you were questioning whether it would start leaking and you spoke about your previous one having a motor that doesn't work very well and it is something that you didn't really like to use, so do you see yourself, now, with a changed perception, to use it again?

INTERVIEWEE: Yes, I do, definitely. I think that it is much better than what we had, so I will, I mean, even the rest of our department is using it a lot more than what we did originally.

INTERVIEWER: Brilliant.

INTERVIEWEE: So I do think it is much better.

INTERVIEWER: Okay, and, out of interest now, you say that the rest of your department is using it. Did you show your colleagues how to use it?

INTERVIEWEE: Yes, so there was the one, there's 2 other teachers doing grade 10 science and the one is quite experienced. She had seen similar sort of designs, so she was quite comfortable with using that and so I didn't really have to tell her too much about it, but the other one who's also fairly new, she and I sat together and pretty much went through all the different things that was shown to me at the training.

INTERVIEWER: Awesome, and did she feel just as comfortable?...

INTERVIEWEE: Yes.

INTERVIEWER: Did she enjoy it?

INTERVIEWEE: Yes, she said that she also felt that it was clearer on the way that she did it, last year, so this year she's had a better idea of what was going on.

INTERVIEWER: Awesome, perfect. Would you recommend in-service training to other teachers when it comes to this piece of apparatus?

INTERVIEWEE: I would recommend it

INTERVIEWER: Reasons?

INTERVIEWEE: Reason being because, as I've already said, it's comfortable. It's not so pressurised. It's obviously useful. You never stop learning, so you might as well try and get as much as you can and even if it's just getting one extra bit of information that changes something. It is still valuable.

INTERVIEWER: Brilliant. Will this training help you and your learners to do the required activities and illustrations related to waves in the future?

INTERVIEWEE: I think so, based on what I've done with my learners already. I see, I have noticed that they seem to be able to draw, say, wave-fronts more better or clearer, more better than the previous year...

INTERVIEWER: Okay.

INTERVIEWEE: So they do seem to be getting the concepts and as, when I was teaching them the different properties, they seem to grasp that much quicker than the years before when it was all individually split.

INTERVIEWER: Brilliant, so you actually have seen...

INTERVIEWEE: Yes.

INTERVIEWER: The difference in your learners, after receiving the training and actually using the apparatus in class.

INTERVIEWEE: Yes, exactly.

INTERVIEWER: Awesome, that's amazing, okay, and good feedback. Did the training, using hands-on equipment, change your perceptions about how you teach waves?

INTERVIEWEE: It did, it shows, for me, the approach obviously did change, but it also shows me that, like showed me that there was nice ways to link everything together, where before, I didn't use to link it because I was scared of the confusion, where here, it showed me that it was easier to link it and actually remind them of the concept rather than just forget about the fact that they don't exist because that's usually what we would do, so we would just focus on reflection, not consider any interference, not consider any refraction or anything else that could slightly be present. Where now, they say, why does this have a funky shape and then the learners can tell me, it's because of this, it's because of that. It kind of tied it all together.

INTERVIEWER: Awesome, and then you used phET simulations to teach waves. How is the use of the physical science equipment that you had different to the simulations?

INTERVIEWEE: The simulations can, sometimes, be limited, so I find, especially, it’s okay when you do like a single wave and you are looking at amplitude and wavelengths and stuff like that, but some of the simulations, in terms of, say, like wave-fronts. I find them very limited. They're often really either related to water or to sound and it's quite difficult to find a planer one, so with the simulations out there, they're quite limited and, to me, they don't really. They kind of reinforce the concept I'm trying to teach not really aid in actually teaching them.

INTERVIEWER: Okay, brilliant, whereas do you feel that the ripple tank apparatus actually helped aid in teaching them.

INTERVIEWEE: Exactly

INTERVIEWEE: Yes, I do. For me, I felt especially when you want to set it up, you can literally set it up to how you want and how the question of that learner was, so if they say, okay, well what happens if this is the case and that's the case, you can literally set it up and let them try it out. Where with the phET is quite limited by what you can actually set up and and you might need to have 2 different simulations going, trying to get them to figure out between the 2, their 1 idea.

INTERVIEWER: Awesome. How has the in-service training, that you attended, helped you prepare for your lessons on the foundational concepts of waves?

INTERVIEWEE: I think it is, because originally, we used to not do so much practical and just teach them the theory, where having the ripple tank and doing the training it has kind of reinforced me that sometimes it's better for them to actually kind of play with it and see things before they do like the calculations which is what we started with, so it's a good, I find it was nice, especially with this year, cause I did change, compared to last year, obviously cause of the training. It's nice when they do have, kind of, like a mental image of what's going on and they can imagine what's going on because they've, kind of, already seen it. So that did help.

INTERVIEWER: And it doesn't mean. necessarily, that they have to understand everything to begin with. You're just showing them asking them what they see and then even going back and doing it again and saying, okay, well, you mentioned you saw this, now you've seen it again. This is what it actually is.

INTERVIEWEE: Cool.

INTERVIEWER: Okay, would you continue using the ripple tank apparatus in your lessons to teach waves?

INTERVIEWEE: I would continue to do that, yes. It is, I think, vital, in terms of the way that we teach waves to use it, as well as, I think it's got great benefits, as I've already said, compared to something like a simulation or a stationary diagram drawn on the board

INTERVIEWER: Awesome, and I know you personally don't teach grade 10, I mean grade 11, grade 12, but do you believe, now that you've shown your other teachers the apparatus, they would use the apparatus in the other grades.

INTERVIEWEE: I'm not entirely sure because I don't, from what I understand of a grade 11 and grade 12 syllabus, that we have chosen to do, they don't go over the waves again unless it's like the electromagnetic spectrum and with that they wouldn't use a ripple tank.

INTERVIEWER: And that's basically due to the subject assessment guidelines

INTERVIEWEE: Yes.

INTERVIEWER: Perfect, that the school basically follows

INTERVIEWEE: Yes.

INTERVIEWER: Awesome, brilliant, and then, is there anything that you will do now, after the training, that you did not do before? You already mentioned that you did change your aspect or approach. Can you elaborate a bit more on that?

INTERVIEWEE: Okay, so as we said, or I said earlier. Initially, we would just do, so say the fundamentals and then do the wave equation and calculations relating to that and then going to each property, so reflection, refraction, diffusion, if we had time, cause we also usually did this at the end of the year and then interference, so usually we would either drop out diffusion (diffraction) and do very brief interference and that's usually what we do and now we have a bit more time to go through all of them, so with that, we have changed the fact that we do them as individual topics. We still do them as individual topics, but we show them and discuss the different properties, so throughout, so it's not just like here's the fundamentals. Here's the calculations, here's reflection. They are exposed to the reflection. They hear the terms before they even start to really go into it, so it's more of a mix than individually, it would be like theory, calculation, reflection, refraction. Each individual property...

INTERVIEWER: And doing the prac right at the end.

INTERVIEWEE: Yes.

INTERVIEWER: Okay, awesome. Are there any other comments that you'd like to bring up about the training and about the use of the apparatus within the classroom.

INTERVIEWEE: I think the training, I feel that it could, it maybe could have been a smidge longer because I would have love to pick more of
your brains and figure out more different, like, tricks that you use and things that you say and techniques that you do, so I think a longer training could have been more beneficial, but then, again, obviously, if you're there for a very long time, you might remember it more, so maybe multiple, if that works, so I think because it was beneficial, it would have been really nice to have it, I don't know, more in depth, so show the things that we don't necessarily do in the school because even when you're trying to understand, it's nice to know further then, what they really do in the school and I think it could've been quite useful if we could go deeper than what is usually covered...

INTERVIEWER: Awesome.

INTERVIEWEE: by the curriculum, you know.

INTERVIEWER: Perfect, that commences the post semi-structured interview.

APPENDIX R: TRANSCRIBED SCRIPT FOR THE SEMI-STRUCTURED POST-INTERVIEW, TSHUMA

INTERVIEWER: Okay, so today is the 15th of March, we are with Participant C, during the post semi structured interview questions. Thank you very much, I do know it is a hectic day.

INTERVIEWEE: Yes

INTERVIEWER: But at least it's the end of the term.

INTERVIEWEE: Yes

INTERVIEWER: What I'm going to be asking, now, is just questions about the training in general.

INTERVIEWEE: Okay

INTERVIEWER: And then, just now we will be approaching the video stimulated recall recording.

INTERVIEWEE: Okay

INTERVIEWER: Okay, so in the training, were the explanations on the equipment clear and helpful?

INTERVIEWEE: Very clear and helpful, I learnt a lot.

INTERVIEWER: Perfect, in what way did the service training that you attended affect your attitude towards practical work.

INTERVIEWEE: with practical first learners observing, it helps them understand the concept easier, so it really changed a lot for the teaching and learning in class.

INTERVIEWER: Okay, so even if it didn't you can also tell me if it didn't change your attitude, but do you feel that it did change your attitude?

INTERVIEWEE: I would be lying if I said it didn't change because physically it did make a positive impact.

INTERVIEWER: Good, okay. in what ways did the in service training affect your confidence.

INTERVIEWEE: Me, it was positive, basically. Everything that I learnt, it helped me and the thing that I discovered, that I didn't know that makes life easier for me, teaching. So, it really changed a lot.

INTERVIEWER: Good and are there any examples that you can tell me which helped you.

INTERVIEWEE: Yes, a lot, just as I said, initially. The last demonstration was done maybe some 20 years ago on the ripple tank. So, now I think the one that I liked, most of all, they talked about the effect of speed. Remember it remains constant, yes, then I saw when she changed the medium that it can also be, speed can also change.

INTERVIEWER: Lovely

INTERVIEWEE: So practically, I mean, I've learnt a lot on that, practically, when you were here…

INTERVIEWER: Brilliant

INTERVIEWEE: Not just theoretically only, but I saw it happening.

INTERVIEWER: Brilliant.

INTERVIEWEE: Yes.

INTERVIEWER: Because then you've basically answered the next question...

INTERVIEWEE: Yes.

INTERVIEWER: The next question says, in what ways did the in-service training affect your science content knowledge?

INTERVIEWEE: Yes, in a way, that means, I gained, I learned, practically things, theoretically, yes, we know, but practically, I saw it, but some things can happen and I saw diffraction, I saw, what do you call this? Change, how do you call the reflection. Where is this? It's running away?

INTERVIEWER: It's the end of term that's why.

INTERVIEWEE: Relationship between wavelength and frequency, yes, and then also the, what you call this, the effect of [inaudible] on diffraction. It's really, I saw it happening, yes.

INTERVIEWER: Good.

INTERVIEWER: Perfect, so did you benefit from the in-service training?

INTERVIEWEE: A 100 percent, I did. I really benefited and, in future, I think, the starting point will be the ripple tank and then from there I start the theory of waves.

INTERVIEWER: Okay, and what did you like the most about the training?

INTERVIEWEE: Basically I would say the demonstration of the ripple tank, which had been a long time since I saw it happening, so, basically, the training was, the ripple tank, it helped me. It made me gain confidence, not only to, it's not easy just to mention things, theoretically. From that, I'm telling you next thing, when I went to my class, I knew what was happening and I knew how to handle concepts knowing that really in practical they happen the way they're supposed to. Because it is not always easy to talk theoretical without having the practical aspect of view.

INTERVIEWER: Good.

INTERVIEWEE: Yes

INTERVIEWER: And did your perception of the ripple tank change after the training?

INTERVIEWEE: I think, in a way, basically, ripple tanks, I have never used it. I didn't have confidence in it, so after seeing it happening, so that means now I can see that all the things about ripple tank, they really apply to what is written, especially in our content or in our curriculum, so my perception changed for positive, to say it really does work. It really shows what is happening in our, especially, curriculum of that level. It's just up to scratch.

INTERVIEWER: Good. Would you recommend the in-service training to other teachers?

INTERVIEWEE: I basically will, but I will even, if there is a way, because in most schools we lack resources, so if there could be a way, especially independent schools, I will advise that most of these schools that don’t have equipment should also get this kind of training. I will be happy.

INTERVIEWER: Good, and are you willing to, what you learned, are you willing to show your colleagues, so that they're also able to use the ripple tank?

INTERVIEWEE: Basically, I have been talking to my, because we are a group of schools. I've told other guys from queens and another one to say I had the privilege to get training with the ripple tank and my learning has been so easy. If so, I encourage them that they should be a time when we should be doing it together. They should come here when we start doing waves, so then we do it together with their learners...

INTERVIEWER: Yes.

INTERVIEWEE: So if there's a way, they should also receive training. I recommend that they should be trained.

INTERVIEWER: Brilliant, and if you use simulations, previously, to teach waves, how was the use of the equipment different?

INTERVIEWEE: All right, as I always say, I do, I remember, so I think, with practical. It's always easier compared to simulation. Yes, simulations you can see them but they forget, but practically, it always stays there, so I think with the real practical, it also helped a lot, than simulation, so I will still stick to the practical effect of the ripple tank. Instead of simulations. Yes, they can help, if you don't have, but if you have, it's always best to do it with the ripple tank.

INTERVIEWER: Good, and how has the in-service training, that you attended, help you prepare for your lessons on the foundational concept of waves because I remember you saying, previously, that you don't normally use practical, especially for grade 10. Has this changed your idea of doing it for grade 10 or not?

INTERVIEWEE: A lot because as I always say, I'm a chemistry major, so with physics, everything I learn, I take it to my advantage, so it changed a lot, was normally with physics, it's my major yes, but I always enjoy chemistry, but now, with practical, it changed me a lot and make me enjoy it more.

INTERVIEWER: Good.

INTERVIEWEE: Yes.

INTERVIEWER: Good, okay, so I observed that you chose not to use the ripple tank with your grade 10's this year, so explain, to me, when you would see yourself using the apparatus, if at all, in the future.

INTERVIEWEE: Yes, I think, the challenge, basically, was about our timetable our setting because I need a double period with practical's. If only I had time, I was going to use the ripple tank, so now I told my learners, right, we have this ripple tank now, of course they won't have the privilege to use it now because they're already done with the topic, but the next grade, what I'm going to do, I'll have time with them. That means I will ask for double period then we will always use the ripple tanks, so next term, I mean next year, if possible, as I promised this other one again, if they want to see it, I can demonstrate some time for them so they can know it works.

INTERVIEWER: Perfect, and would you, you've already mentioned that you see the relevance in using the ripple tank for your other grades. Is it something that you would consider using for your other grades?

INTERVIEWEE: Grade 11, definitely. I'm going to use it next term when we're dealing with our diffraction definitely, it's going to be there, I'm going to use that one for 11, grade 12. Unfortunately, it's, I've done the topic doppler effect, so I won't use that one.

INTERVIEWER: The topic already..

INTERVIEWEE: Yes.

INTERVIEWER: Perfect, and would you be willing to send me a photo, if you do use it, you can. If you don't use it, don't worry, but if you do use it, in future, please, just send me a photo, just for, it won't be part of the study...

INTERVIEWEE: Okay.

INTERVIEWER: At all.

INTERVIEWER: It's just for me to...

INTERVIEWEE: For you to, yes.

INTERVIEWER: To see if you're using it and if you're happy...

INTERVIEWEE: No problem.

INTERVIEWER: And you give me feedback.

INTERVIEWEE: No problem, basically, when you do practicals, you always the directors, they take pictures, so I'll take it

INTERVIEWER: Oh Lovely.

INTERVIEWEE: So

INTERVIEWER: Great

INTERVIEWEE: On Facebook

INTERVIEWER: Cool, despite not using the ripple tank to teach your grade 10's the concept of waves. Did the training help you in any way, to teach it this year?

INTERVIEWEE: A lot, when you guys came with your supervisor I think there's a lot that was explain that I learned a lot. I think, I remember, there's one concept that I enjoyed, I don't know what is it about. I think it was just about speed and wavelength and frequency. I think I learned something there and then when she also talked about, I think, was it about destructive and constructive interference. What do you call that, I forgot….

INTERVIEWER: Superposition.

INTERVIEWEE: Superposition, yes. I learned a lot there when the supervisor was explaining that concept on the board, so I learned a lot.

INTERVIEWER: Lovely.

INTERVIEWEE: I learned a lot.

INTERVIEWER: Is there anything that you would do now, after the training that you did not do before?

INTERVIEWEE: Basically, yes, as I was saying, I think, with grade 10, the first thing, as I said, because since I learned a lot before even when they were demonstrating, so I think the best thing, the basis of waves, first, is just to have learners demonstrate ripple, I mean, ripple tank effect and then let them identify, tell them what is happening there. Then, from there, I can develop the topic of waves without even telling them what is happening, I was just asking questions, what is happening here and there. Then, as an introduction, then I develop from there, practical.

INTERVIEWER: Perfect.

INTERVIEWEE: Yes

INTERVIEWER: And do you have any other comments about the training, in general?

INTERVIEWEE: I think it came at the right time and it came for the right topic, for the waves because I basically, if I get the, my learners, not my learners physically. When you go for a moderation waves. Yes, they don't perform very well, most learners in waves. Here and there they do, but I think, now, for what I can say I learnt a lot and I have interest in the topic of waves, though I didn't like, it's not my favourite. I'm a chemist, I like chemicals, but now, I think I enjoy teaching the topic, so because of the training, the explanations and I always say that it's never too late to develop, so I developed and, I mean, I was developed, in fact, a lot on this topic...

INTERVIEWER: Good.

INTERVIEWEE: Which makes it like it now to teach

INTERVIEWER: Okay, and so basically, at the end of the day, even though you were a teacher that decided not to use the ripple tank in the class...

INTERVIEWEE: Yes.

INTERVIEWER: The training still helped you with your knowledge in the topic.

INTERVIEWEE: A lot. It also developed me in the topic because, yes I teach it, it's not my major, so I still need to be developed in some topics especially the topic of waves, yes I enjoy it here and there, but some things I did need to know and ripple tank, as I'm saying it helped...

INTERVIEWER: Good.

INTERVIEWEE: It's been, I don't know, 10 years without seeing it happening.

INTERVIEWER: Brilliant...

INTERVIEWEE: Yes.

INTERVIEWER: Perfect, thank you.

INTERVIEWEE: Okay, mam.

APPENDIX S: TRANSCRIBED SCRIPT FOR THE SEMI-STRUCTURED POST-INTERVIEW, CRAIG

INTERVIEWER: Okay, so today is the post semi-structured interview and the video stimulated[recall interview with Participant D. Thank you very much.

INTERVIEWEE: Okay, thank you very much.

INTERVIEWER: Right, so when we look at the post semi-structured interview questions. Were the explanations on the equipment and the activities clear and helpful when we were doing the training?

INTERVIEWEE: Yes, they were so clear because it wasn't difficult for me to follow the things which I got from the training.

INTERVIEWER: Perfect, in what ways did the in-service training that we did for you effect your attitude towards practical work.

INTERVIEWEE: Yes, it improved, because I was able to see a lot of things and I learned a lot of things. You know, learning, you don't stop learning. You always learn, so I learnt a lot of things from the training, so it was okay.

INTERVIEWER: Lovely, In what ways did the in-service training effect your confidence?

INTERVIEWEE: It improve my confidence because now I was able to, I was now having something to show the kids and it was live, so it made me more confident after seeing all the production of the waves and the stuff.

INTERVIEWER: Perfect. In what ways did the in-service training effect your science content knowledge.

INTERVIEWEE: Yes, it improved my content, especially when I was talking to the professor…

INTERVIEWER: My supervisor.

INTERVIEWEE: Your supervisor, yes.

INTERVIEWER: Yes.

INTERVIEWEE: Yes, she was bringing up a lot of concepts and there is some things which where, I also used in explaining things to learners. It was so helpful

INTERVIEWER: Okay...

INTERVIEWEE: It was so helpful

INTERVIEWER: And give me some examples of what you learnt from her.

INTERVIEWEE: Like, when introducing the topic, not telling the learners what you know. Getting the details from them, what they know. What do they think is going to happen? It helped a lot.

INTERVIEWER: Good.

INTERVIEWEE: It helped a lot, yes.

INTERVIEWER: Okay, did you benefit from in-service training and what did you like best about the training, so there's 2 questions there?

INTERVIEWEE: Yes, I benefited a lot because I got some more information on the topic and, also, I got some, I can say, some ways on how to explain some of the things in the topic.

INTERVIEWER: Good.

INTERVIEWEE: Yes.

INTERVIEWER: And then what did you like best about the training?

INTERVIEWEE: Like, the thing I like best about the training is this thing of getting more information. You know, information is really essential, so you need more information. There were some things which I had problems in explaining, now I got a way to explain those things, yes.

INTERVIEWER: And as a teacher, are you, because some teachers believe or they are scared of letting people know that they need help understanding knowledge, so do you believe, in that training, it did help you understand the section better and therefore, to teach it better?

INTERVIEWEE: Yes, that's correct, most people, I always tell people that, even my learners, I told them, don't be afraid to ask. Don't have that pride of I know everything. No one knows everything, so that training helped me, which improved me in a way because, like I said, there are some things which I didn't know and it quite helped me to, especially in explaining some of the concepts. It helped me a lot.

INTERVIEWER: Brilliant, and I remember you saying, in your original interview. You said exactly that, you said, I also tell my learners to remove their pride.

INTERVIEWEE: That pride, especially when it comes to subjects like Physical Science, even me, I always connect my colleagues, get questions, if I'm not sure I connect with other colleagues, so that, that's how we, it's better to get information than to just sit down and do nothing about getting information. You will remain down...

INTERVIEWER: Yes, down to earth.

INTERVIEWEE: To earth, yes.

INTERVIEWER: Yes, of course. Perfect, did your perceptions of the ripple tank change after the training?

INTERVIEWEE: Yes, it changed quite a lot because before, using the ripple tank, I was just thinking that it is something which is not that necessary, but after the training, after using it in class it is now changed, I realise there's a lot in the ripple tank than what I thought.

INTERVIEWER: So do you believe, now, that there is an importance to maybe use it?

INTERVIEWEE: Yes, there's quite an importance. It's quite important. It helps a lot using. It helps a lot.

INTERVIEWER: Good, would you recommend the in-service training to other teachers?

INTERVIEWEE: Yes, I think it's very important, even making up a programme where maybe an hour, 2 hours, 3 hours, just sitting, doing the content part of it. Training people and to me it was quite helpful.

INTERVIEWER: Good, and now that the school has the apparatus, would you mainly sit down with your other Physical Science teachers to show them the apparatus?...

INTERVIEWEE: Yes

INTERVIEWER: So that they can also use it.

INTERVIEWEE: Yes, I was actually asking this other friend of mine, who's teaching at the other school, that he might come check and I'll show, I want to show him, especially on how to use it for the topic of Grade 11 that is coming up, so that he'll see how is to use it.

INTERVIEWER: Lovely...

INTERVIEWEE: Yes.

INTERVIEWER: Good. Brilliant, will this training help you and your learners to do the required activities and illustrations related to waves in grade 10?

INTERVIEWEE: It helps quite a lot, both on my side and to the learner's side and actually, this test which they wrote, like the end of term test, the way they approach the questions which has to do with waves. It was so, I could see that this is because of how they got those demonstrations which we did in class.

INTERVIEWER: Wow, so you actually say that you observed in their written test...

INTERVIEWEE: Yes.

INTERVIEWER: That the way that they answer it was different to years before...

INTERVIEWEE: yes, it was a bit different. I was different, yes.

INTERVIEWER: Wow, and you believe that, you really believe that it is from...

INTERVIEWEE: you know, from seeing and doing it is very essential.

INTERVIEWER: Wow.

INTERVIEWEE: It is very essential, it's easy to explain something which you have seen live, than something which you just have a perception, just think it's there, not seeing it live.

INTERVIEWER: Wow, Lovely, okay, well that's good feedback. Did the training, using hands-on equipment, change your perception about how you teach waves, from what you used to do.

INTERVIEWEE: Yes, it's changed quite a lot, yes it changed quite a lot because now it's more of, you are seeing things happening. It's easy to explain because, also, the learners will be seeing what will be happening.

INTERVIEWER: Good.

INTERVIEWEE: Yes, it was quite easy.

INTERVIEWER: And, previously, you did mention, earlier, that you didn't really think the ripple tank was important...

INTERVIEWEE: Yes.

INTERVIEWER: And now you feel differently?

INTERVIEWEE: Yes, now it is different. It's very important. It is user-friendly, to explaining it, to using it, to learners, it's very easy.

INTERVIEWER: And did you, once you, when you see the apparatus, it looks quite complicated, but once we have trained you, did you feel at ease and that it's not actually that complicated to use.

INTERVIEWEE: Yes, when I saw the equipment, initially, before using it. to me it was just some things, but after the training, after I realised there's a lot of things which can be done with the equipment and there's quite good stuff which comes out of that from the equipment which you can give to the learners which is quite well.

INTERVIEWER: Good. If you use simulations in lessons. I didn't see you using simulations, but if you do, for other sections and even previously, to teach waves, how is using equipment different to using those simulations.

INTERVIEWEE: The difference is, when I'm using simulations, it's something which is not physical. It's something which is done, like, with a screen. They don't have that feel, so the perception will still be there like, so it's viewing it live and letting them help you set up and view part of the thing and it's easy for them to understand...

INTERVIEWER: Brilliant.

INTERVIEWEE: it is easy for them to understand.

INTERVIEWER: Okay, good. How has the in-service training that you attended help you prepare for your lesson on the foundational concepts of waves?

INTERVIEWEE: Right, it helped me a lot was when during the training I picked up where exactly should I start. Where, how should I introduce the concept of waves. It was easier for me to pick where to start, so that we can come up with the learners as we go into the wave section, yes.

INTERVIEWER: Okay, good, would you continue to use the hands-on equipment, the ripple tank, in your lessons to teach waves, in the future.

INTERVIEWEE: Yes, I would do so. That's why I was saying, I was telling this friend of mine that he can come, then I will show him how to do with the grade 11's. Now I am saying, now I'm taking it to grade 11's because there is diffraction, remember, and all this stuff in grade 11. They will also use it.

INTERVIEWER: Good.

INTERVIEWEE: Because it's user-friendly.

INTERVIEWER: Good, because you've just answered the next question...

INTERVIEWEE: Yes

INTERVIEWER: Which was, would you use the apparatus to teach in your other grades…

INTERVIEWEE: Yes, I will definitely because it's user-friendly.

INTERVIEWER: Good, and did you feel that you were forced to use the equipment or because of the training. Did you, when I came to observe you...

INTERVIEWEE: Yes.

INTERVIEWER: Did you choose to use the apparatus or did I tell you, you have to use the apparatus?

INTERVIEWEE: I chose to use it because, for me, it was easy. It was very easy to use the, to explain my stuff using the equipment rather than using the textbook orally and the way I use to do before, yes.

INTERVIEWER: Okay, good, brilliant...

INTERVIEWEE: Yes.

INTERVIEWER: And is there anything that you will do now, after the training, that you did not do before? Other than, actually, using the apparatus, is there anything else?

INTERVIEWEE: Yes, well, like what I said, the information is very important Ive been telling other guys that there's this stuff which you can use which means it's very easy for you to explain all, the whole topic on waves and which is very essential

INTERVIEWER: Good.

INTERVIEWEE: Yes, it is very essential...

INTERVIEWER: And is there any other comments you want to add about the training that we haven't covered?

INTERVIEWEE: I think the training was very essential. It helped me a lot and I just want to thank you for the training. It was quite helpful.

INTERVIEWER: Good.

INTERVIEWEE: Yes.

INTERVIEWER: Okay, brilliant, thank you very much...

INTERVIEWEE: Thank you.

INTERVIEWER: So that concludes our post semi-structured interview.

APPENDIX T: AUDIO STIMULATED RECALL INTERVIEW WITH THE TRAINER

The following represents the questions set out for the semi-structured audio stimulate recall interview with the trainer. The trainer chose to recall information in order of the interventions. Therefore, recalled information pertaining to Participant D is seen first, followed by Participant A and then Participant C. The recorded times seen in brackets are the relevant clips from each intervention recording that is used to support each question. If a number of clips where identified, the clip seen in bold was the clip chosen to be replayed back to the trainer to recall her memory about that particular section of the relevant intervention.

Participant D

1. Participant D asked whether the ripple tank would leak (**00:07:58)** indicating a lack of confidence in the apparatus and maybe relying on his past experience with the apparatus. Would you agree?
2. I noticed that you would draw diagrams on a piece of paper. What was your reasoning for this? (00:11:57-00:12:06; **00:12:54-00:13:50**; 00:20:16; 00:22:55; 00:24:45; 00:31:12-32:55; 00:34:15)
3. I noticed that the participant doesn’t really ask questions but rather repeats words and phrases that you say during the intervention and often says the word "OK" and "Yes". Do you recall this? (**00:12:50-00:13:50**; **00:19:40**; 00:31:55; 00:58:12-00:58:40)
4. You continuously tell the participant to ask the learners 'What do you see?' and 'What changes?'. What is your reasoning for doing and saying this? (**00:19:50-00:20:10**; 00:28:18; 00:30:30; 00:35:00)
5. You also suggest during the training that the teacher should practise beforehand. Why do you suggest this? (**00:28:48**; 00:30:00; 00:35:09)
6. Looking at the whole nature of the training, did you find the participant more receptive than interactive? (00:15:00-00:16:21; **00:21:00-00:22:32**; 00:58:12-00:58:40)
7. During the training, the teacher indicated that the apparatus is important for Grade 11 because that is where the concepts of diffraction, refraction are covered and are applicable for using the apparatus (**00:59:50-01:00:09).** He mentioned that at the Grade 10 and 11 level the learners need to understand the foundational concepts because if not 'it would be something else' (**01:00:19 – 1:00:45)**. Therefore; through these clips, overall

- I believe that the participant did have an understanding about waves but was not very familiar with the apparatus. Would you agree?

Participant A

8. At the beginning of the training the participant had quite a negative perception on the ripple tank (**00:0:31)**. The participant asked whether it would leak while she was pouring the water into the tank, thus indicating a lack of confidence in the apparatus **(00:09:00)**. The participant acknowledged that the school did not really use the ripple tank and rather used the light kit and the slinky spring to teach the topic **(00:29:15-00:29:35)**. The participant also stated that the current ripple tank that the school owns is wooden in nature, leaks and has a faulty motor [(0:09:00 and 0:12:00 and during the concept of reflection (0:12:58)]. Knowing the above, do you think we changed her perception of the ripple tank through the training?
9. I noticed that you drew less diagrams when training this participant on the ripple tank. What was your reasoning for this? (00:16:03)
10. The participant did not ask questions but rather stated certain aspect ie: that she would ask the question to her learners relating to the crests being the lighter lines and the troughs being the darker lines (**00:16:50**). The participant also stated during the training the way in which she would normally project the images produced while using the ripple tank onto the roof **(00:06:30)**. Would you say this was a sign of confidence**?**
11. Would you agree that although the participant was quite knowledgeable, the participant is believed to have still learnt something during the intervention which seemed evident through her excitement when we introduced her to
    - the use of the stroboscope (00:07:30 – 00:07:50);
    - the use of the ripple bar controller to change the frequency and thus the wavelength and particularly when viewed through the stroboscope **(18:41 – 19:20)**
    - the image seen on google maps linking diffraction to a real-life scenario **(33:40 – 34:50)**
    - The concept of diffraction when view through the stroboscope indicated by the words she used of "that’s cool" and "trippy" (**00:37:35 – 00:38:08**).
12. During the training you are heard saying "that you ask learners to predict but that it works before they come into class because there are many things that can affect things"

(00:25:26 – 00:25:40). Why did you concentrate on making the teacher aware of practising beforehand?

13. Please explain why you saw it important to indicate that learners should be allowed to predict and explain what they see? (00:39:15; 00:52:25)?
14. During the training you use very descriptive real-life examples to describe certain phenomenon to the teacher ie: pile of sand **(00:34:50)** and about water waves (00:43:00). What is your reasoning for this?

Participant C

15. You ask the participant if he has ever used a ripple tank before and he replied by saying that it was not as a teacher but rather long time ago when he was doing his teacher training **(00:03:20)**. This was further back up at **00:55:55** when he admitted that the last time he used it was during his teaching training in 1999 when he was still in college. Do you recall?
16. Do you agree that this indicates that he has not been trained on the ripple tank before despite him regularly attending workshops of which the last being in 2018?
17. You asked if he had a slinky spring and he indicated that he mainly only uses a rope and textbook to teach the section. Do you recall? **(00:09:03-00:09:20).**
18. We introduced the stroboscope to the participant 15minues and 30 seconds into the training. Do you recall that he was not very sure on how to use the stroboscope (**00:15:56-16:09**)?
19. Again with this participant you suggested "that you ask learners, letting them describe what they see (00:10:40; **00:16:55)**; 00:22:10) "what do you think will happen" and once asking such questions that he should expect answers (**00:23:00 -00:23:28**) [Further clips: 00:34:20; 00:44:29; 00:46:40; 00:53:35].

    Why did you concentrate on making the teacher aware of asking learners to interact in this way?
20. In the previous two trainings, as well as during this one you highlight a number of misconceptions. During this particular training you elaborated on the misconception about the relationship between frequency, wavelength and speed using the equation. (**00:20:15-00:21:00**). What is your reason for highlighting such misconceptions during the training?

21. At **(00:30:35)**, the participant asked whether he should introduce diffraction in Grade 10. He appeared to be concerned that we were covering the concept because he seemed to think it was a Grade 11 concept. His thinking was correct. Do you believe this is a clear indication of him knowing the curriculum order regarding the topic of waves?
22. At the end of the training he was concerned about his conceptual strategies ie: evident by asking the question as to whether or not the apparatus should be used in Grade 10. Do you believe this is a sign of him already thinking how to use this new piece of apparatus in his lessons for Grade 10 and thus possibly trying to link his static PCK and dynamic PCK? (**00:51:26-00:53:00**; 00:53:48 – 00:54:47; 00:55:00)
23. Although having been trained on the equipment the participant still acknowledged that he needed to practise more (**00:51:26-00:53:00**) Do you recall? This was stated by the participant before you mentioned it to him during (00:55:15).
24. Looking back at the whole nature of the training, did you find the participant interactive and interested in what you were saying and drawing? Shown through the way that the participant was agreeing, accepting and repeating the things that were being said? (00:09:00 – 00:13:30; 00:19:15 - 00:19:47; 00:20:00 – 00:22:00; 00:32:00-00:32:30; 00:35:55; **00:40:05-00:41:06**)
25. The participant found joy in using the stroboscope and loved the visualisation of the waves as he would often say "nice one" or "true" **(00:26:40;** 00:35:29**)**. He was also heard saying "this is perfect the learners will enjoy this". Do you think that this indicates that he enjoyed the training?

In general:

26. During the teacher training you did not train the teachers on only how to use the apparatus but also included how to use the apparatus in relation to the curriculum and thus how to link the concepts with the apparatus through demonstration. What was your reason for this?
27. Is there anything else that comes to mind when thinking back the all three training sessions?

APPENDIX U: TRANSCRIBED SCRIPT FOR THE AUDIO STIMULATED RECALL INTERVIEW FOR THE TRAINER

Part 1.

INTERVIEWER: Okay, so we are, it's the 06/03 and I am with a trainer doing a interview, recall interview on the training of all three participants. Thank you very much. Okay so we starting with participant D because we trained in this particular order. In the clip of seven seconds 53 [Audio: Participant D is heard asking if the ripple tank will leak while we instruct him to pour in the water]. Okay so he basically questions whether the tank would leak, do you think this is indicating a lack of confidence in the apparatus or past experience?

INTERVIEWEE: Ja I think it was probably past experience, because I myself recall the wooden ripple tanks that tend to leak. So I think it was based on experience and probably his not using maybe those that he has because it leaks.

INTERVIEWER: Perfect. Okay and then at 12 minutes 54, now I actually went and tried to see if I could type in, but I couldn't. There you go [Audio- the trainer is heard drawing. The trainer is drawing a basic wave diagram and uses it to illustrate light rays hitting the crest and trough on the wave. She does this to illustrate the idea of refraction and to explain the light and darker bands which are seen in the projection under the ripple tank]. Okay so I noticed with this particular participant you drew a lot of diagrams, what was your reasoning for this?

INTERVIEWEE: It is far more easy to explain when a person can see what you are talking about, than just talking. I feel that you relate, you make meaning of the words when you see the representation of what is being said and often when you have two different kinds of representation, say the actual ripple tank and then you can confirm it with another drawing, and you confirm it with another explanation, I think it is a better way to get the concept across and to get his participation, his mind and his eyes and everything participates in what you are doing.

INTERVIEWER: Perfect. In the same clip, I don't know if you heard but the participant doesn't really ask questions, he more repeats what you're saying words and phrases and often just says yes and okay. Do you recall this and do, what do you take from his reaction?

INTERVIEWEE: I think what I usually believe especially about teachers is, they don't want to lose face. They don't want to give away that they didn't know and since it's a professional, I would not want to indicate to that person that I'm actually aware of the fact that you don't know. So I wait for responses if I don't get it, I carry on not to make the person self-concisions and not being able to attend.

INTERVIEWER: Perfect, thank you. Okay 19 minutes and 50 seconds [Audio-The trainer is suggesting to the participant that they should ask their leaners what they observe and what they see. This was done while showing wavelength and frequency of a wave using the ripple tank]. So in this clip you here yourself asking or telling the teacher to ask learners what do they see, what do you think is happening, what is your reasoning for that?

INTERVIEWEE: I want to get across the idea that teachers should not teach top down but involve learners. So if you ask learners what do they see they can just be honest and say exactly what they see, because you don't ask for an explanation. So they can just see exactly, say exactly what they see and then ja in that way involving the learners and then afterwards you can explain what they were seeing. But you will have to as I told the teacher, you will have to if they don't if you don't draw their attention to what you want them to see, then the moment will pass. So if they don't mention what you really want, then you ask again.

INTERVIEWER: Perfect. Okay there three clips for this, but I'm going to just play the first one 28 minutes 48 seconds [Audio- the trainer suggests to the participant that they will have to practise using the apparatus beforehand/before a lesson]. So again, you suggest to the teacher that they even though they've had this training, that they really need to afterwards go and practise using the apparatus again. Why do you suggest this to the teacher?

INTERVIEWEE: At first for me a technical reasons you have to know what to do, how much water to put in, where to put the light, how deep you should put the vibrator stick. But also, to rethink the practical, to rethink the sequence in which you are going to do this. I guess I must have, I should have emphasized that more, to tell the teacher that you should have, you should also do this practical and go through your own work sheet or your own session in your mind while practising this. And not nearly seeing whether everything works.

INTERVIEWER: Perfect and like I say or mention that you actually said it three times in this training, so it is something you really did reiterate to this particular participant. Okay then 21 minutes is the one that best describes it. So, let's go to 21 [Audio- The trainer is heard introducing frequency through the use of what was observed in the ripple tank when the speed controller was adjusted. The trainer is giving the participant ideas of how to introduce frequency using the ripple tank and through the number of vibrations observed in the water and linking it to the phrase 'per second'.]. So, in this clip you can hear yourself mainly only, which also indicates again you have touched on this, that the participant was mainly listening than interacting. Do you believe this is the case for this participant?

INTERVIEWEE: That would be difficult to say but I got the idea that he was not comfortable in answering. Maybe self-conscious, I can't say that he did not know these concepts, because I've only just met him. But time constraints necessitated to go on if you don't get the response you want and you don't want to create the idea for, in that person that I think he can't. He is not up to it and he doesn't have the concept so, when he does not respond I just go on.

INTERVIEWER: Make sense.

INTERVIEWEE: If he were a learner, I would have done it differently.

Part 2.

INTERVIEWER: Okay so as I was saying, the last thing that I would like to discuss with participant D, is that during the training the teacher indicated that the apparatus is important for Grade 11. Because that's when one covers diffraction and refraction and the concepts that we were dealing with were applicable to the apparatus and he mentions this in minute 59, ag come on, number 59 50 so that's perfect [Audio: Participant D is heard discussing with the trainer that the apparatus is important for Grade 11 for diffraction, refraction]. Okay so I don't know if you, do you want to hear that again?

INTERVIEWEE: No, I didn't hear very well, but I guess what he reveals here is his knowledge of the grade 11 curriculum and that he anticipates that this can be used. I liked it because one can see that he was thinking about even though they do reflection and refraction with light, He appreciated that the reflection and the refraction we did with the ripple tank could be very well used in explaining the concepts related to refraction and reflection.

INTERVIEWER: Lovely, perfect. So, in all in all with participant D when I look back, I personally believed that he did have some knowledge on the curriculum and where things fit in and didn't show confidence in the use of the actual apparatus. Would you agree with that?

INTERVIEWEE: Yes, I agree that I got the impression that he enjoyed the training a lot and that he was quite thrilled about the stuff that he saw. And he understood the implications that if his learners could see that, that would help them. Ja so I think all and all I think he learned a lot.

INTERVIEWER: Brilliant, thank you. Okay so now we move on to participant A, the training for participant A. Okay so at the beginning of this training the participant had quite a negative perception on the ripple tank and this is heard at, quite early in the training, at 31 seconds. Just because we reiterated what we were discussing in the pre-interview about her not stating that the ripple tank has problems of its own. She also then questioned whether it would leak while she was pouring the water into the ripple tank and that was, we'll listen to a clip at 9 minutes. She then also acknowledges that they don't really use the ripple tank and instead use the light kit and the slinky more. And that her particular ripple tank is wooden, that leaks, and the motor is slightly faulty. So, what I want to find out from these clips which I'm going to play now, is at the end of it, do you think we changed her perception on the actual apparatus herself? Or itself? So, let's go to 31 seconds [Audio: Researcher reiterating that she remembered the participant saying in the interview that participant doesn't really use the ripple tank and rather uses the slinky, the light kit and simulations]. And then again at 9 minutes. And then at 29:15 [Audio: The researcher suggests that the participant pours the water into the tank. While the participant pours the water in she is heard asking if it is going to leak]. Okay and then at 29:15 [Audio: The trainer suggests to the participant to ask the learners to think why and where the blocks come from, that they are observing. The researcher also indicates that the participant stated that she normally uses the light kit. The participant then indicates that they do use the ripple tank but not using multiple wave fronts, only to illustrate a single pulse] Okay and then when she talks about it being faulty [Audio: incorrect audio]. Oh no sorry, that was that one [Audio] and then where was this one 12:58 [Audio: The participant is heard saying that their current tank has a faulty motor which is unreliable]. So, you can hear there she talks quite a lot about a previous experience with the ripple tank. So, do you think we did change her perception on it?

INTERVIEWEE: Ja because I think her negativity about the ripple tank was mainly based about on the faulty ness of her apparatus. Because she, I got the impression that she is a teacher that likes to do demonstrations and practicals. Because she often refers to, I did that with my kids and I do this, usually I do this. So, I think she's not a teacher that shies away from doing practical's. And I think the main reason why she didn't like the ripple tanks because she had problems with it. And for one I got the impression that she definitely will use this, you would need to see in her lesson observation whether she actually did use it. And she also came across as quite knowledgeable about what the ripple tank can do as if she did use it in the past.

INTERVIEWER: Perfect, then also with this participant I noticed compared to the previous participant you drew less diagrams. Was there a particular reason for this or is it just because you felt that you mention now, that she was quite knowledgeable?

INTERVIEWEE: Yes, I got that impression and, but I think this, why did I draw, I can't remember, there was less space. I know, if I recall I got the impression that she understood easily, and she was aware of what I was talking about.

INTERVIEWER: You are correct, because there is a place actually where at 16 minutes 50 which I can play for you if you'd like to recall? But you were about to show her a diagram of the light at the crests and the troughs and she actually mentioned to you that that is a question she asks the learners. And so at that point we identified.

INTERVIEWEE: Okay then that is exactly.

INTERVIEWER: Okay.

INTERVIEWEE: I had the impression that she's quite knowledgeable.

INTERVIEWER: Perfect. Okay so that covers basically the next question. Would you find also in the training again, she wasn't a participant that particularly asked questions, but she did interact in the sense that and like you mentioned already. She stated how she likes to show the phenomenon on the roof. And she stated how yes, she does ask that type of question. Would you say that this was a sign of confidence?

INTERVIEWEE: I definitely think she's more confident, yes. The reason why she didn't ask questions is probably because she knew, she knew the answers. Different from the others that didn't ask questions because they did not want to reveal that they didn't know. Because of the other remarks she made, she contributed to the discussion, rather than just saying yes or repeating what I said. She made her own contributions to the discussion.

INTERVIEWER: Lovely. Okay now I'm going to play you a number of clips and I would like you to find out what you take from these, these particular clips? So 18:41 just going to start it there [Audio: The participant is using the stroboscope to view the wave fronts while the researcher adjusts the frequency of the waves – the participant is heard saying 'it is cool' and laughing]. Okay so that’s first one, the next one is at 33:40 [Audio: The trainer shows the participant a real life example of diffraction happening with water waves around Saldanha bay, Western cape, South Africa. The participant is heard saying 'oh, yes' in an excited jovial manner]. Okay and then 37:35 [Audio: The participant is heard saying 'its pretty cool, the kids always think that this is pretty trippy anyway, they are going to think this is so trippy'].

INTERVIEWEE: Yes, she had the typical reaction that I also have and when I look at these things. Every time I see it, it’s beautiful, it’s remarkable. And I enjoyed her absolute enthusiasm about what she saw not only for her learners but for herself. But she also realised that her learners will find this very interesting and as she said trippy. But it tells me that she enjoys the science a lot. And she saw the significance of what we have showed her, and it was obviously the first time that she used a stroboscope. I think she said that and the possibilities of using that. Ja she was definitely quite intrigued with what she saw.

INTERVIEWER: Brilliant thank you. And then again with this participant at minutes 25 and 26 seconds and again and 25:40 seconds. You tell her to ask her learners to predict the situation as well as making her aware that she needs to practise before hand. So this is the second participant you obviously have done exactly the same thing, do you want to reiterate why you tell the teachers to ask the learners that?

INTERVIEWEE: Yes, I would like them to ask the learners to predict because that is the way scientist work. They see something and then they need to repeat the experiment, they need to predict and see if what they thought will happen actually happened. And it also involves learners to be, to help them to think critically about what they see. However, that is a technique that teachers has to practise to get learners to actually be participating in what they see and what they think they are seeing and what they think the reasons are. Ja.

INTERVIEWER: Perfect, thank you. And then lastly you use very descriptive real-life examples to describe the phenomenon's to this particular teacher and that is heard at 34:50 [Audio: The trainer is heard using an analogy of a pile of sand that is placed over a gap that would fall from her hand and through the gap allowing us to see sand through the gap but not under the barriers creating the gap and then asking is that what we expect from particles? Is that what we expect from waves?]. And then again at minute 43 [Audio: The trainer is discussing waves in the ocean and that waves in the deeper water travel much faster than the waves at the beach]. What is your reasoning for using such descriptive real-life examples?

INTERVIEWEE: The one with the sand was actually an example that one can use when you explain, when you teach the dual, what's the word?

INTERVIEWER: Dual nature.

INTERVIEWEE: The dual nature of particles and of waves. I did not use that with the other teachers because it's a little bit off the scope for this, for the ripple tank demonstration. But since I saw that this teacher was more perceptive, I thought I could use this explanation. But I always like to show that science is not far off, science is not out there it is actually about real life. So that is, that's why I would, what I like to bring in the real-life stuff when we work with this science concepts.

INTERVIEWER: And it was very interesting because out of all three participants she in her pre-interview actually made mention how she believes that science needs to be realistic and it needs to be real. Linked to real life examples. So I found it just very interesting that with the one participant that really believed in making science real to her learners. You had done exactly the same for her. So it was just a…

INTERVIEWEE: Ja.

INTERVIEWER: Great…

INTERVIEWEE: Whether it was coincidence or whether…

INTERVIEWER: Yes.

INTERVIEWEE: I sense that I don't know.

INTERVIEWER: No it was just great to see…

INTERVIEWEE: I can't say that it was a…

INTERVIEWER: No.

INTERVIEWEE: Conscience decision.

INTERVIEWER: Okay so now we move on to the last participant, participant C. Okay so let's go to minute 3, no where's 3:20 [Audio: The trainer is heard asking the Participant if he has ever used a ripple tank. The participant is heard replying by saying only long ago, not during his teaching time, only when he was studying to become a teacher]. And then again right at the end [Audio: The trainer, researcher and participant are heard having a discussion about needing to practise using the ripple tank before using it in a lesson because often things don't go the way one planned and because learners love to laugh at teachers. The participant also indicates that he is happy and has learnt a lot and the last time he saw it demonstrated was long time ago in 1999 while still at college]. So from these two clips you, the first clip you asked whether the participant had used a ripple tank. And he admitted it was long time ago and it was being demonstrated but not him actually using it as a teacher. And then he in the clip of 55 minutes he said it was further back when he the last time he used it was during his teaching training in 1999. When he was still in college. Do you recall after hearing that?

<u>INTERVIEWEE</u>: Ja, that is exactly what he said, and I got the impression that he actually never put his hands on one. He saw that being demonstrated but he never put his hands on one.

<u>INTERVIEWER</u>: Great and the reason why this is so important is because in his pre-interview, excuse me. Pre-interview he stated that the last teacher training he attended was in 2018, which was last year. And so it was very important for me to stipulate through the training that actually even though he had gone to teacher training it wasn't necessarily on the apparatus, that we were particularly showing.

<u>INTERVIEWEE</u>: Ja.

<u>INTERVIEWER</u>: So, again do you agree that this indicates that he has not been trained on the ripple tank?

<u>INTERVIEWEE</u>: No, he definitely didn't not know, he did not know he was, everything was new to him.

<u>INTERVIEWER</u>: Brilliant. You then also asked if he had a slinky spring and he admitted he mainly used a rope and textbook. And then you asked him if he mainly relies on the pictures and he agreed. So I'm going to play it to you now and you can maybe agree if you recall or not [Audio: The trainer asks the participant what he normally uses to teach pulses. The participant indicates that he uses a rope. The trainer asks if he has a slinky. The participant says that he uses a textbook to show. The trainer then asks if he mainly relies on pictures and the participant answers yes]. So yes, again he admitted he didn't have a slinky spring and he mainly uses a rope and text book and then you asked him if he mainly relies on the pictures and he agreed.

<u>INTERVIEWEE</u>: Ja, so one gets the impression that he actually only uses a textbook because you can't really use a rope for a wave. That wave, the friction damps the wave almost immediately. You can try it but with a rope you can't really show a

wave that travels longer than this. Than a metre distance. So, if he says a rope, I thought that maybe he just not want to reveal that his actually not using, it may be that he used a rope. But you can't show much with a rope because you can only make one pulse and because of friction, that pulse will die down very, very quickly. So…

INTERVIEWER: Okay.

INTERVIEWEE: There's, he can't show wave length, he can't show frequency, he can't show super position. With a slinky you can do that, but not with a rope.

INTERVIEWER: Thank you. And then at 15:56 [Audio: The researcher is suggesting to the participant how to hold, turn and use the stroboscope]. So that's, ja there see [Audio: *extended on the previous audio which was not needed*]. So, in that clip you hear us telling him how to hold the stroboscope, how to turn it. And you tell him the speed at which to use it, so again indicating that he hadn't used a stroboscope.

INTERVIEWEE: Definitely, it was the first time he ever saw that.

INTERVIEWER: Okay, I have down here that with this participant again. You reiterate that he needs to ask his learners what do they see? What do they think will happen, but you have answered this question previously. So, we'll move on to the next one. In this training as well as previous trainings, you highlight on some misconceptions. This particular training you highlighted the misconception about the relationship of frequency, wavelength and speed. What is your reason for highlighting such misconceptions? But I'm just going to play the clip before you answer…

INTERVIEWEE: Okay.

INTERVIEWER: The question [Audio: The trainer is explaining to the participant a typical misconception that teachers should address. At this point the trainer suggests that the equation can be introduced to the learners ($v = f \times \lambda$) because learners think that if the frequency is higher, the waves move faster. The trainer indicates that this is incorrect because for the same medium the v value remains constant because if frequency increases the wavelength decreases].

INTERVIEWEE: Yes, I can recall that I also talked about that with the first participant. I can't recall whether we addressed it with the second participant. But never the less. That is an important thing for me to discuss because I find that that is

a question that's often asked. In multiple choice form or whatever format, that learners don't get the right answer because they think the speed varies if the frequency varies. They would rather believe that the wave length is constant. So they tend to not realise that if you have the same medium then the speed is the same. But if you have the same source and you don't change the source. So you don't change the frequency, then the medium, then the speed or the, then the frequency's constant. And then the wave length and then the wave length and speed can change. So this relationship between speed, wavelength and frequency is not well understood.
INTERVIEWER: And why do you believe that it's important that teachers have an understanding of this misconception when they are teaching the section?
INTERVIEWEE: I think for one main reason is that they should know how to listen for the answers of learners. So that they can pick up the existence of misconceptions when learners answer. And then know how to address it. Not telling learners sorry this is wrong but know how to phrase question. So that learners become uncomfortable with the idea they have and being willing to change it to the correct scientific idea. But if a teacher doesn't know about the misconceptions, they will not. They will either just think that is the wrong answer, tell me again what's the right answer or they will not know the questions to ask to lead the learners to conceptional change.
INTERVIEWER: Brilliant, okay then at 30 minutes 35 [Audio: The participant asks if he should introduce diffraction in Grade 10. The trainer indicates that she believes he should do the illustration when he covers diffraction. The participants is heard saying 'during Grade 11, we talking Grade 11'. The trainer agrees.]. So in this clip you hear the participant seeing that we are doing the diffraction and then getting quite flustered in questioning, oh wow do I need to do diffraction in grade 10. And we reiterate to him that actually no it is in grade 11 like his correctly thinking. So do you think this is an indication showing that he does have an indication about curriculum order? In the sense of what section goes in which grade?
INTERVIEWEE: I think definitely so, that is the impression I got from all the teachers that they actually know which fits where in the curriculum. Being reluctant to teach something in a different place or just make learners aware. Is something that that I also see that reveals to me that a teacher sticks to the curriculum very strictly. And they don't allow themselves to go beyond the curriculum if the situation asks for that. Or if they can just explore and present the learners with other ideas. So in a

sense the knowledge that we revealed was good, he knows the curriculum. But he's definitely not, it seems as if he's not willing to or reluctant to go outside what the curriculum prescribes.

INTERVIEWER: And do you believe that's pretty much the same idea that you also got from participant D? Which was the first training we did?

INTERVIEWEE: Ja I think so. I think they, but it may be a time constraint. It may not reveal so much about the teachers themselves as a time constraint. Or being assessed by department officials, I don't know. But I think if a teacher is really confident in the content, they will deviate little bit and come back. Without losing much of the knowledge that they have to teaching the curriculum.

INTERVIEWER: Okay, the next clip 51 minutes 26 there's two questions that I'm now going to ask on this particular section [Audio: It is the end of the training and we are all discussing if we have covered everything and have covered all the illustrations using the ripple tank. The trainer asks if the participant has any questions. The participant indicates that he is fine but wanted to ask if in Grade 10 he is supposed to use the ripple tank. The researcher indicates that it is up to him and what he would want to do. The trainer suggests ways he could explain refraction in Grade 10 to get the idea of the change of wavelength. The researcher recaps on how it can be used to introduce a pulse, wavelength and frequency in Grade 10. The trainer is heard again reiterating that one should ask the learners what it is that they see and what it is that they predict, with the concept determining which of the two questions one would ask]. Okay so through this whole conversation you hear him talking and obviously his thinking about his conceptional teaching. How to incorporate it and where to incorporate it. Do you think this is a sign of him trying to connect his static and dynamic PCK in the sense of what he thinks he should be doing and what he will actually end up doing?

INTERVIEWEE: I got the impression, not only with him but with the other teachers as well that they were very enthusiastic. They saw the possibilities of this piece of equipment and they realised how much it can be of help. In introducing the concepts to the learner and how much they will enjoy it. So definitely he was at that stage perfectly willing, enthusiastic and planning to use this. It may be interesting to see whether he actually does it. But at that moment he was definitely aware of the possibilities and definitely had in his mind that he will use it because it's going to help him and he's going to help the learners. But that often happens in such a situation that just after that particular moment you are enthusiastic, you are psyched up. And then when life happens, it fades away. We will have to see.

INTERVIEWER: Okay no that's perfect. And then lastly also through that clip. Do you believe that this participant because you are saying enjoyed the training?

INTERVIEWEE: I think all of them did. All of them enjoyed the training. All of them learned a lot. Even the participant that we feel was the most confident in her content knowledge. Not that the others were not confident, they were all confident, I think. But the one participant just revealed her content knowledge more than the others did. Even she learned because she also handled the stroboscope for the first time. And I think the way we sequenced the concepts how we taught it, they were all quite taken up by the idea, I think. It was very useful for them, we just hope that they take it to heart and use the equipment.

INTERVIEWER: Brilliant. And then you also have touched on this but through generally now and we look back at all three trainings. You didn't just set up the apparatus and showed them how to use it. You really linked the situation, the curriculum, their prior knowledge, the learner misconceptions, the fact that they had to practise, the fact that they had to get the learners engaged. What was your main reasoning for connecting all the dots to the training and not just showing the teachers how to set it up and use it?

INTERVIEWEE: I think the very short reason is, I'm a teacher at heart. Which probably means that I have a certain knowledge since I have a lot of experience of teaching the concept and teaching students and teaching with the equipment. So I know what the things are that you should look at. I know what are the misconceptions. I know that if you don't plan a demonstration, may not happen the way you foresee it. I know how learners respond and I know what's going on in their minds when they respond. I know how things that we learn now, will be important later. So and I would like to impart, if at all possible, my knowledge to the teachers. In almost the same way I would like them to impart their knowledge to learners. So but as I've said before, if it were the learners that I'm teaching, I would do it quite differently, but I did not ask the teachers so many questions because I don't want to make them uncomfortable and make them feel that they are in some kind of inquisition. And not being confidant in answering, maybe answering wrong or something like that. But yes, I think they enjoyed it and I enjoyed it.

INTERVIEWER: Great and did you find in general the participants quite receptive to the training?

INTERVIEWEE: Yes, they definitely were. I think at that moment when they were thrilled about what they would see. I think that ja, but I hope that they were not just taken up in the moment and that it stayed there. But that it would go further.

INTERVIEWER: So they basically, you do agree that they were open to the idea of being trained on something to further benefit them? And so they weren't really reluctant in?

INTERVIEWEE: No they weren't reluctant. I did not find that with any of the trainers that they were reluctant. They were definitely open.

INTERVIEWER: Perfect and then lastly is here anything else that comes to mind with any of the trainings? Or participants that you would like to highlight?

INTERVIEWEE: Not that I can think of now. No not that I can think of now.

INTERVIEWER: Okay so.

INTERVIEWEE: I think we've touched on everything.

INTERVIEWER: Brilliant. Okay.