TEACHING PHYSICS TO ADOLESCENTS

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Introduction

This report provides a critical account of my time [c] assisting in a local secondary school for the "Physics in Education" module at the University of Surrey. The objective of my project at the school was to interact with students and teachers, observing and assisting in physics lessons. The aims were to gauge how physics is taught at this level (GCSE, and A-Level), how well understood it is by the students and the student-teacher interactions. During my time there (28 hours over 4 separate visits), I observed and assisted with many classes [c] while also observing students learning physics across different levels and ages. The final objective of my project was teaching the students for one lesson while being supervised. Due to the Covid-19 pandemic this final objective was not achieved. However, my planned lesson was undertaken by the teacher with her own sourced worksheets and plans which I assisted with as outlined below and detailed in the presentation.

The School

All Hallows is a secondary school established in 1961, located in Farnham, Surrey, teaching students from ages 11 to 18 years, split across separate years and classes [d]. It has a current enrolment of 1,220 pupils and is bigger than the average sized secondary school in the UK at 965 pupils [1] [2]. Despite the large student population, it is well-structured and sufficiently caters to individual student needs. The science department is excellent; an adequate size with several capable physics teachers, and is representative of diversity across age and gender. This excellence is proven by the success of the students, in 2017 there was a 100% pass rate for all A-levels "with students excelling in subjects such as math and physics" [3].

Figure 1. All Hallows Roman Catholic School emblem [2].

The lessons and my contribution

Most classes had a mixture of work sheets, problems and experiments enabling me to assist. Similar to the teacher's teaching style, I went from student to student helping them through their problems. Having tackled the same problems through my education I was able to address their issues, simply through demonstrating how I solved similar problems. Below, I provide a brief description of a few such lessons.

Ripple-Tank

Figure 2. Students investigating waves with a slinky [6].

As seen in the presentation this was the lesson where we performed my project. The lesson aimed to teach the students basic wave characteristics which began with a slinky [6] demonstration [11] and was ended with a Ripple-Tank demonstration [9]. Their final understanding of these demonstrations were shown with a work sheet with questions to answer in the end [a]. While helping the students with this it was clear the Ripple-Tank was not as useful as the slinky in achieving the aims (detailed in presentation). For example, they quickly grasped the concept of the wave motions, transverse vs longitudinal. However, they had a difficulties in making the connection between the characteristics wavelength(λ) velocity of wave(v), and frequency(f). Here, I gave them the simple mathematical relationship to enable another way of understanding it, which had positive effects.

Eq 1. $$v = f \, x \, \lambda$$ *"The wave equation"*

Leaf biopsy

This was a Biology lesson [10] dissecting leaves and inspecting them under microscopes. The students were split into pairs with one microscope each. This was a very interactive lesson where I attended to each pair, showing them what they were looking for, and upon them finding results outlining what they meant. I observed how each pupil struggled with similar problems, with the only material difference being the time it took them to solve the problem. This showed me that gauging how much time and space to give individual students was just as important as the guidance and advice I gave them.

Figure 3. Picture of the students performing science experiments at All Hallows school in the physics classroom where most of my observations took place [2].

Future careers in physics

During the Year 9's physics lesson, we discussed career opportunities in physics, with employer profiles handed around to the pupils. The physics teacher, Mrs. Dickson asked me to talk to the students about my career journey so far, so I gave a short ten-minute presentation on my academic career in physics, my motivations for pursuing my physics degree, the trials and tribulations faced, and what my future aspirations were. The students were engaged and interested in a current physics student hearing about my experiences as it allowed them to know what life at university, as a physics student was like. I was asked a lot of questions and I believe that discussing my experiences was helpful for those students generally aspiring to attend university, and specifically aspiring towards a career involving physics. I also learned here that these students had all studied appropriate subjects that they are challenged with in 1st year physics at university.

An incite into physics at univeristy

I attended a final year class [d] with students applying to universities. They were very interested to speak with me and ask me questions about what it is like to be at university, and what is expected of you in the physics classroom. Due to this interest, I gave an informal talk and hosted a personal 'Q and A' session for the students, informing them of what level of physics is used, while naming some modules, bringing to their attention the importance of mathematics in physics. This was well received by the students, who eagerly asked more questions. Unfortunately, there was not enough time to address all queries and I suggest a physics student representative visiting these schools in future would be beneficial in challenging the popular notion that physics is impossibly hard at a university level.

Other activities achieved

On my first day at the school two students gave me a guided tour of the entire school, I used this time to ask them about their opinion on physics and other subjects. I found out that they ranked physics as one of their harder subjects, alongside mathematics and chemistry.

The school allowed me to attend the morning teacher meetings, discussing the main issues with the entire school staff, with such items as: struggling students, and student progress and achievements. I saw this to be very useful, with great communication, allowing the status and progress of the students to be regularly updated and supervised.

During breaks and lunchtime, the teachers took turns supervising the premises and the students' activities. Mrs. Dickson allowed me to join her on one of these activities. The students were lively with each other and having fun and any interaction between them and the teaching staff was courteous. Showing that even on the playground discipline and respect of teachers was high. It was evident in the classroom that this was important for the educational progress of the students, as we will see next.

Pupil-Teacher Interaction in The Physics Classroom

The timing at which the students attended the class made a complete difference on their comprehension and progression. As noted by some of the teachers, a physics class on a Thursday afternoon would achieve substantially less than the exact same class on a Monday morning, due to the pupils being tired and demotivated after a week and a full day's worth of classes. This caused the teacher to spend more time managing the students rather than teaching. I observed this to be much less of an issue in the top difficulty classes [d].

Figure 4. All Hallows Year 9 students interacting with teacher [2].

Physic teachers who built a rapport with students and had respectful exchanges, as mentioned above, did a lot better with communicating their lessons clearly. This, as I observed was due to the pupils' willingness to listen and ask questions out loud once stumbling. Unafraid of belittlement from fellow students due to the teacher's positive attitude towards the questions allowed students to learn honestly and openly. Additionally, teachers who had control of their classes allowed other students to answer the questions their peers asked, proactively. This allowed for a more relatable exchange amongst peers, in relation to the physics problem. Physics concepts can be very abstract, with different analogies working for different students so this process was helpful in working through difficult concepts.

The Pupils Understanding of Physics

I observed many different physics teachers, physics classes, years, across various difficulty levels [c]. Depending on students' abilities they were taught either the simple basics or the in-depth physics. For example, a year 9 group at a lower level difficulty class was set with naming the following states of matter in Fig.5, and completing a work sheet [b] with pictures sentences already provided. In contrast, the higher set was tasked with drawing them from scratch and creating their own sentences to describe the states of matter. This showed me a good quality of physics teaching, as opposed to a 'one size fits all' approach since students actively progressed, based on their own learning needs. The higher set teaching strategy would teach a much more solid understanding of the physics, but for those struggling the basic goal was still achieved in the lower sets.

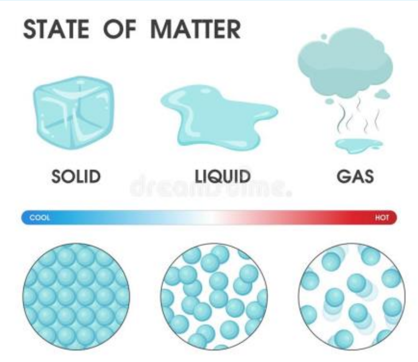

Figure 5. Picture of state of matter for H_2O. An example of what the lower set students were given for the understanding of states of matter [8].

Conclusion

Upon reflection, I saw that physics is taught concisely at this school, with a broad and appropriate curriculum, especially when relating it to current 1st year physics in universities. I observed two main issues with physics lessons, the first being the time the physics teacher is given to teach the students these sometimes complex and abstract ideas, and the second being the mandatory strict adherence to the curriculum. While the latter helps maintain a fair and uniform teaching level across the country, it fails to account for individual student learning capabilities. The teacher is unable to mold and manipulate the teaching style and material to the learning ability and style of the individuals in their classroom. These issues could be solved by giving the physics teacher more freedom and more time, however, this is unlikely to happen since the time would have to be sacrificed from another area of education.

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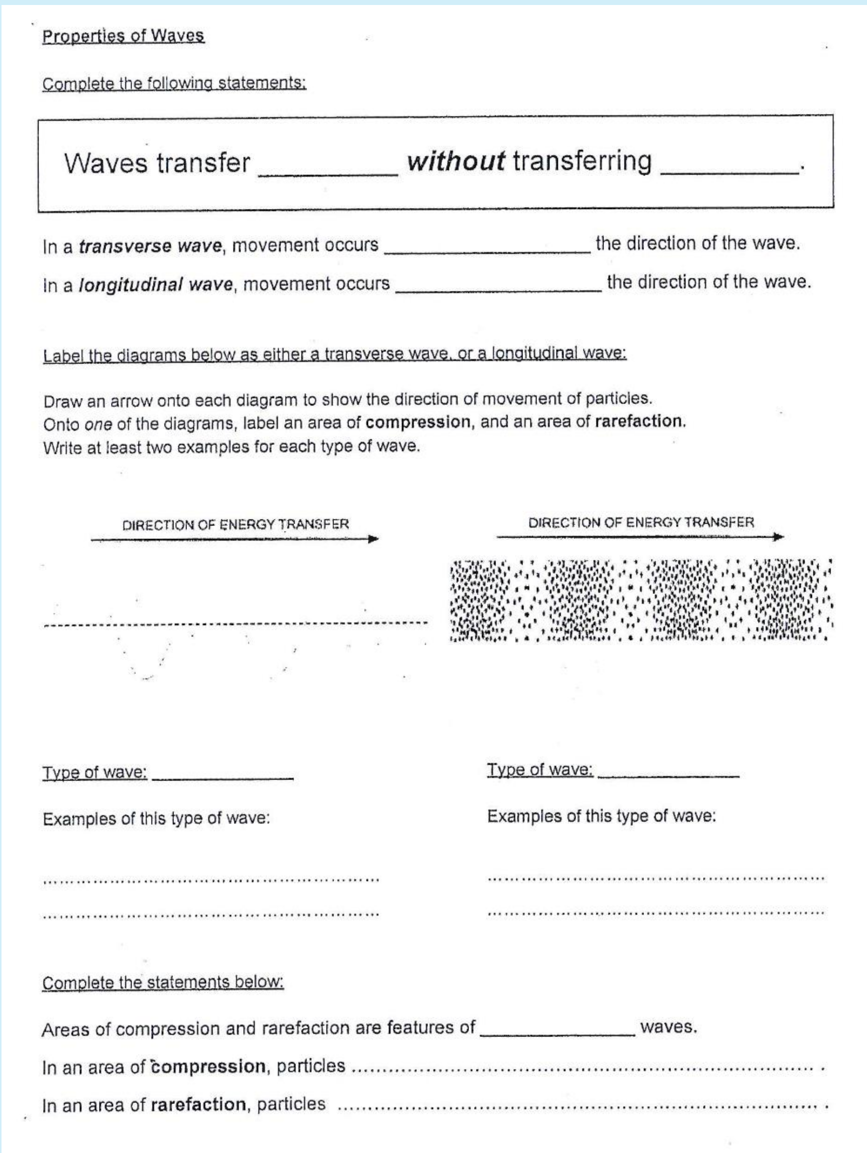
Appendix

[a]

A picture of the work sheet used in project, created by Mr. Hatchard [7]



Properties of Waves

Complete the following statements:

Waves transfer __________ ***without*** transferring __________.

In a ***transverse wave***, movement occurs ____________________ the direction of the wave.

In a ***longitudinal wave***, movement occurs ____________________ the direction of the wave.

Label the diagrams below as either a transverse wave, or a longitudinal wave:

Draw an arrow onto each diagram to show the direction of movement of particles.
Onto *one* of the diagrams, label an area of **compression**, and an area of **rarefaction.**
Write at least two examples for each type of wave.

DIRECTION OF ENERGY TRANSFER

DIRECTION OF ENERGY TRANSFER

Type of wave: _______________

Examples of this type of wave:

……………………………………………………

……………………………………………………

Type of wave: _______________

Examples of this type of wave:

……………………………………………………

……………………………………………………

Complete the statements below:

Areas of compression and rarefaction are features of ________________ waves.

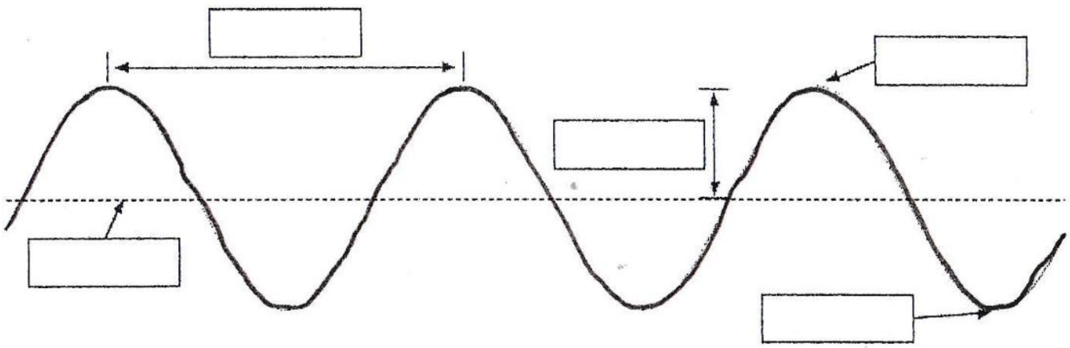
In an area of **compression**, particles …………………………………………………………………… .

In an area of **rarefaction**, particles …………………………………………………………………… .

Appendix A

Use words in the box to complete the diagram, and the definitions below it. Some words will be used more than once and some words may not be used at all:

Hertz	period	metres	dip	seconds
peak	wavelength	trough	crest	
frequency	amplitude	oscillation	equilibrium line	



_______________ - the top of a wave

_______________ - the bottom of a wave

_______________ - the level if the wave flattened out

_______________ - a repeated action back and forth or up and down

_______________ - the number of waves that pass every second (measured in _______________)

_______________ - the time it takes for one complete wave to pass (measured in _______________)

_______________ - the distance along one full wave cycle (measured in _______________)

Appendix A

[b]

A picture of the worksheet mentioned in "The pupils understanding of Physics" with Fig.7, created by Mrs. Dickson, assisted by myself in its implication and learning. Belonging to All Hallows School [2].

2 Fill in the gaps in these sentences using words from the box. You can use each word once, more than once or not at all.

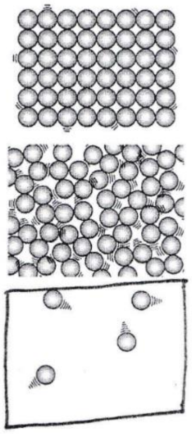
close together	container	compress	contract	expand	far apart
gas	liquids	shape	solid	strong	volume	weak

The three states of matter are solids, ____________ and gases.

Solids have a fixed shape and ______________, so they cannot be poured and are difficult to ______________. This is because the particles in solids are ______________ and are held in a fixed arrangement with ______________ forces.

Liquids have a fixed ______________, but they do not have a fixed ______________. They take the shape of their ______________ and they can be poured. The particles are held ______________ by fairly strong bonds, but can move past each other in the liquid.

Gases do not have a fixed shape or volume. They ______________ to fill any container they are in. The particles in a gas are ______________ and there are only ______________ forces between them.



3 A thermometer has a red liquid inside it.

k What happens to the particles in the liquid when the thermometer gets hotter?

____

l How does this affect the volume of the liquid?

____

m What happens to the particles in the liquid when the thermometer gets colder?

Appendix B

[c]

A list of classes I attended and assisted with during my time at All Hallows school in Farnham. This time spanned from 13th Jan – 11th March. The caption “Worked on resources” refers to periods I was giving the experimental equipment to work on preparing for my planned project. “Meetings with Mrs. Dickson” was periods to discuss and work on my project. “Meeting with Freddie”, was meeting with a physics graduate from the University of surrey who has previously completed the Physics in education module, and is now becoming a teacher and discussed with me how to be in the classroom, and his path into teaching.

<table>
<tr><th>Date</th><th>Period</th><th>Year</th><th>Set</th><th>Subject</th><th>Teachers (Initials)</th></tr>
<tr><td rowspan="6">13th January</td><td>1</td><td>8</td><td>2</td><td>Physics</td><td>LDI</td></tr>
<tr><td>2</td><td>10</td><td>5</td><td>Biology</td><td>TCO</td></tr>
<tr><td>3</td><td>10</td><td>1</td><td>Physics</td><td>TDI</td></tr>
<tr><td>4</td><td colspan="4">Worked on resources</td></tr>
<tr><td>5</td><td colspan="3">Meeting with Mrs. Dickson</td><td>TDI</td></tr>
<tr><td>6</td><td colspan="3">Meeting with Freddie</td><td>FO</td></tr>
<tr><td rowspan="6">5th February</td><td>1</td><td rowspan="2">13</td><td rowspan="2">5</td><td rowspan="2">Physics</td><td rowspan="2">LDI</td></tr>
<tr><td>2</td></tr>
<tr><td>3</td><td>11</td><td>2</td><td>Chemistry</td><td>MBD</td></tr>
<tr><td>4</td><td>9</td><td>1</td><td>Physics</td><td>EBR</td></tr>
<tr><td>5</td><td>7</td><td>5</td><td>Biology</td><td>TCO</td></tr>
<tr><td>6</td><td>10</td><td>3</td><td>Physics</td><td>TPA</td></tr>
<tr><td rowspan="6">12th February</td><td>1</td><td>10</td><td>1</td><td>Physics</td><td>MWI</td></tr>
<tr><td>2</td><td>8</td><td>2</td><td>Physics</td><td>LNI</td></tr>
<tr><td>3</td><td>8</td><td>1</td><td>Physics</td><td>MSI</td></tr>
<tr><td>4</td><td colspan="4">Worked on resources</td></tr>
<tr><td>5</td><td>7</td><td>5</td><td>Physics</td><td>MSI</td></tr>
<tr><td>6</td><td>10</td><td>3</td><td>Physics</td><td>TPA</td></tr>
<tr><td rowspan="6">11th March</td><td>1</td><td>7</td><td>2</td><td>Physics</td><td>LNI</td></tr>
<tr><td>2</td><td>8</td><td>2</td><td>Physics</td><td>SSP</td></tr>
<tr><td>3</td><td colspan="3">Meeting with Mrs. Dickson</td><td>LDI</td></tr>
<tr><td>4</td><td>9</td><td>3</td><td>Physics</td><td>LDI</td></tr>
<tr><td>5</td><td colspan="4">Worked on resources</td></tr>
<tr><td>6</td><td>11</td><td>3</td><td>Physics</td><td>TPA</td></tr>
</table>

Appendix C

[d]

The school is split into different years and classes of difficulty, they are as follows.

Sets 1-5 is the difficulty levelling for each year, set 1 being the top set and set five the bottom set. Higher achieving students being placed in higher sets.

Year Classification	Ages (Years)
Year 7	11-12
Year 8	12-13
Year 9	13-14
Year 10	14-15
Year 11	15-16
Year 12 “Sixth form”	16-17
Year 13 “Sixth form”	17-18

Appendix D