

*Module Title: Enhancement and Development of Mathematics pedagogical knowledge
for effective teaching of Mathematics at Key Stage 3 Module Code: M6X02214*

*Graduate Diploma in Professional Learning: Mathematics at Key Stage 3
LEVEL 6 Yr Athrofa 2020*

Nichola A Powell BA(ED) Hons QTS

Does exposure to misconceptions in the learning of directed numbers enable children to improve their understanding of the concepts of positive and negative number in a range of contexts?

- 1. Background and Introduction**
- 2. Ethics**
- 3. Literature review**
- 4. Diagnostic test, questionnaire and analysis of results - Before intervention**
 - **The Diagnostic test**
 - **The Questionnaire - how the pupils like to learn before and during Lockdown**
- 5. Intervention pack review**
- 6. Diagnostic test, questionnaire and analysis of results - Post intervention and Conclusion**
- 7. References**
- 8. Appendices**
 - **Appendix A**
 - **Appendix B**
 - **Appendix C**
 - **Appendix D**
 - **Appendix E**

1. Background and Introduction

'Prevention is better than cure' is the mantra I use when approaching misconceptions in the classroom. Being open with pupils about why some questions can lead to many wrong answers is an important way to resolve cognitive conflict from the outset, and can lead to a greater understanding of a topic. However, in the current Covid-19 situation, when we are under lockdown and our educational system has temporarily changed from face-to-face teaching to that of distance learning, I am having to change my approach to teaching. Therefore I am going to investigate whether exposure to misconceptions in the learning of directed numbers enables children to improve their understanding of positive and negative numbers with the use of a distance learning pack that I will assemble.

In order to achieve this, following research into misconceptions and a literature review, I will provide a group of pupils with a series of diagnostic questions on the topic of directed numbers. Then after analysis of the results I will provide them with a distance learning intervention pack, and retest them. I chose the topic of directed numbers as, from my experience, pupils find negative numbers difficult to comprehend. Pupils find their misconceptions frustrating, and as directed numbers are used in so many different scenarios in real life it is a very important topic that needs to be understood correctly. There are many misconceptions that can arise, which offers itself as a good topic to explore and research, and is something I have great interest in. I will also provide the pupils with a questionnaire (Appendix A) to gather their thoughts on how they like to learn both at home and in the classroom. I will tailor my intervention pack to reflect the pupils' opinions, then following the completion of my distance learning pack I will question them again to see if any opinions have differed and if they have found the intervention effective (Appendix B). I will also give them some work containing misconceptions to mark and analyse themselves which will give a good opportunity to see that pupils themselves can spot a misconception, state what the misconception is and correct it. The triangulation of these three research methods will endeavour to draw a conclusion as to whether or not exposure to misconceptions can help a child resolve them.

2. Ethics

The research will be based around a randomly formed group of 16 Year 8 pupils, from a secondary school in South West Wales. The pupils are moderate to high ability, and a mix of boys and girls. They are normally based in three different classes and work at different speeds, but due to the current climate are all being taught remotely and at the same speed. For the purpose of this project, and to be able to analyse I will not differentiate the task. All pupils will have access to the same full teaching intervention pack. Diagnostic tests results will not be anonymous to myself for the purpose of analysing whether or not progress has been made after the intervention, however questionnaires will be anonymous and will not be linked towards any individual. All pupils will be taught fairly and given the same time frames to complete any work set. Safeguarding in Pembrokeshire during this Covid-19 period prevents any face to face or video interviews with pupils from being held, the county has also decided teachers cannot teach live lessons on any platform. This limits the resources I can supply the pupils with and will give a good insight as to how pupils learn without having the face to face support that they are used to. All feedback to pupils is given is through the platform of school Gmail and personal messages on their work in Google classroom.

3. Literature review

Misconceptions are a common occurrence in the learning of pupils, they arrive in many different scenarios and need to be carefully corrected and explained in order for a pupil to gain a productive learning experience. Polya (1945) has four basic problem solving principles, that can assist in aiding and distracting a pupil away from misconception. I will be following his four steps in order to answer the question I have posed 1) Understand the Problem - I will do this through diagnostic testing 2) Devise a plan - following the results I will adapt a learning pack appropriate to the pupil's needs 3) Carry out the plan - I will give the learning pack to the pupils 4) Look back - I will reflect on the 1st diagnostic test, the work the pupils have done and form an opinion after analysing the pupil's 2 diagnostic test results. Looking at Piaget's Theory of Learning (1979) the pupils in my Year 8 classes fall into Piaget's fourth stage of cognitive development, which means they should be thinking in a logical fashion, mirroring the thoughts of Polya's four principles. I will take this into account with the materials I produce to aid their learning by incorporating a task that will test the pupils' knowledge of directed numbers in a logical way.

$-4 + -5 = 9$ (Barton 2014) It is this type of answer that made me want to explore pupils' misconceptions with directed numbers. Pupils sometimes attempt difficult sums with blinkers on, they take away the parts that confuse them and deal with the easy sum that is left behind. Why? Because making the sum easy makes it safer and simpler to cope with, despite the fact it can lead to giving a wrong answer. $4+5=9$, ignoring the minus signs shouldn't make a difference? Should it? Ignoring the negative sign has been a coping mechanism pupils have been using for a long time, because trying to understand negative numbers is a venture into the unknown, and a topic some teachers find is a concept hard to convey effectively. Children are taught from an early age that '-' means take away and '+' means add, so comprehending that these signs can also make a number negative or positive can be a challenge for some to overcome. Olivier (1989) believed that this was due to a fault in the way a person thinks. I question that if a child is taught to think like this at an earlier age, it could remove the cognitive conflict that directed numbers cause. Another interpretation into $-4 + -5 = 9$ could be a misconception derived from pupils being taught that two negatives make a positive. This comes from the knowledge of rules that pupils have been taught, but have misinterpreted, and misapplied. Rules learnt by rote can often be applied incorrectly and if not corrected can cause the pupils problems for a long time.

Both of these interpretations lead me to Skemp and his thoughts on relational and instrumental understanding theories (1987). Relational understanding is derived by working something out and referring it to something you are familiar with. Instrumental understanding is using a formula or rule that you have learnt to carry out a calculation, not necessarily understanding why you are using the process. Both of these theories need to be used together in order to avoid misconceptions. Teaching by rote and theory is not effective without practicing and understanding the skills, so I will be ensuring my teaching pack contains real life examples of how to control directed numbers and that my questions contain cognitive conflict. I like to use the analogy of change in temperature of a room when explaining the direction of numbers, and have learnt that Craig Barton (2014) uses a similar example with the temperature of soup. I will be providing the pupils with a Google Slides presentation to aid their understanding containing my thought model.

Craig Barton is a contemporary educator who is an expert in his field, he has produced many articles and resources regarding misconceptions pupils have with mathematics. His website <https://diagnosticquestions.com/> states resolving misconceptions improves performance. This makes so much sense, and I hope teachers would apply this practice confidently in their lessons. Barton is passionate about misconceptions and has offered support to teachers during this period of lockdown. I have read many articles Barton has written and they have influenced my teaching greatly. There is a quote from Colleen Young on Barton's website that is relevant to all educators, "good questions help us know more about our students' learning and helps us to address misconceptions." This shows how important asking the right questions to our pupils is, we need to know whether a pupil has simply made a mistake or has a more serious misunderstanding. By using questions that are similar in meaning but use different language or phrasing a teacher can establish whether or not a pupil has developed a misconception.

Misconceptions can be missed by bad questioning. A teacher who gives a pupil 12 questions in the same format is likely to assess that the pupil understands the topic should they get the 12 questions correct. However another teacher may find that if the same questions are rephrased, rearranged and re-given to the same pupil they may make several mistakes and more than likely have a misconception. It is important to vary the way questions are posed to pupils so they have experience of a variety of words which mean the same thing, they should be given similar number sentences written in alternate ways. Chambers and Timlin (2013) state that should a teacher miss a mistake a pupil makes and that mistake gets repeated over and over then a misconception could arise. Once the brain practices the same thing over believing it is right, it is hard to relearn the skill. It is important to use varied repeated questions when diagnostic testing to see if a mistake (or misconception) is unknowingly repeated.

Tanner and Jones (2010) suggest that it is difficult for a pupil to accommodate a new perception of knowledge when they have been mis-solving problems for a long time. Should this arise during my project I will need to be careful how I approach this. Explaining a misconception is simply not enough to resolve a misconception without the appropriate approach and reinforcement by the pupil. This could pose a challenge if I were faced with this situation during distance learning. Should I obtain this kind of cognitive conflict I will need to find a good strategy or resource that will engage the pupil and ensure they are willing to accept where they are going wrong.

The theory of constructivism (Vygotsky 1962, Piaget 1967, Meyer, 2009) recommends that pupils should be encouraged to expand on a theory by actively exploring it, for example the active use of number lines at Year eight should be just as acceptable as using a number line in Year three because it visually helps a child to solve the problem. It makes sense when you see the direction in which a number is taking you. I will be encouraging my pupils to make their own number line for use with the intervention pack while they get confident with the subject. Clements and McMillan (1996) suggest that manipulatives can aid pupils' learning and allow pupils to make sense of an idea, and I think number lines would be the best resource for this in this topic.

The theory of Vygotsky's ZPD (Zone of Proximal Development 1979) is very attainable when learning distantly. Though I have used Vygotsky's pedagogy in the past, when reading up on it now during lockdown it mirrors the scaffolding tasks I am setting for the pupils. It gives me confidence to continue in the format I am teaching, though if feedback suggests otherwise I would need to adapt. Distance learning is making our pupils work on their own, away from the security of their teachers and classmates. On one hand as educators we are striving to develop independent confident learners, however I do worry that more misconceptions will

arise following the premature independence that lockdown has forced upon them. Some pupils are following BBC Bitesize, some are being 'educated' by TikTok and Fortnite, some are being taught strategies (not necessarily correct ones) by parents, and some are simply completing and submitting their work just to get it done without worrying if it is right or wrong. There are reliable pupils who are reaching the ZPD which is very reassuring, but it is hard to deliver and monitor this during this period of distance learning. However it is important to include this type of question in my diagnostic test, and it will be very interesting to see the percentage of pupils that get it correct.

'Successful futures' has already made its way into the Welsh classroom. Donaldson (2015) has encouraged teachers to reignite their passion for teaching and for them to teach for purpose. With the reinforcement that numeracy and literacy are skills that must be used across all curricular subjects, it is even more important that pupils overcome mathematical misconceptions in order to apply skills in numeracy based situations across the curriculum confidently and correctly. My learning pack needs to contain numeracy problems with directed numbers that practice activities linked to time zones, temperatures and money. This will allow pupils to use directed numbers in different contexts with confidence.

The new curriculum in Wales (2019) states that to obtain progress in mathematics and numeracy these five proficiencies must be developed into the pupil's learning:

- Conceptual understanding
- Communicating with symbols
- Fluency
- Strategic Competence
- Logical reasoning

When compiling my pack I will endeavour to include these five proficiencies in my activities. The proficiencies are a reminder to teachers of the skills that pupils need to have in order to become independent with their mathematical thinking. Sometimes these skills are overlooked as it is assumed that pupils already use them. By making these proficiencies a requirement in the curriculum it will ensure pupils will have confidence with the way in which they approach mathematics, and teaches them the skills they need to solve problems methodically. My questionnaire asks the pupils to state how they like to learn, so using their input I will apply these proficiencies in their tasks.

Research into theories of how to overcome misconceptions regarding directed numbers through distance learning is scarce. This is due to the fact schools and educationalists have never been faced with a learning situation like the one we are currently in with the COVID-19 pandemic. We have never all had to teach like this. I wanted to include some current observations I have made and that will have an impact on my research project.

Teaching staff, including myself, have had to discover the ability to produce work that is accessible to pupils of all abilities remotely. This is a learning curve and we are still in the early stages of discovering what works remotely and what doesn't. Following the research I intend on conducting with my pupils, I will use their advice and my intuition into producing work that I anticipate will be effective online. This will be a challenge, but it will be essential in providing the best results in order to inform my hypothesis. Another problem I face is participation. It has been said that during this pandemic a bigger divide has been made between rich and poor (Forbes 2020), but with government incentives to provide pupils with technology that divide should have been narrowed, and a large percentage of pupils should all be getting the same

online access and technology (BBC 2020). Yet while resources are put in place using Google classroom, work is photocopied and mailed out, and school maintains contact with pupils and their families, it is also noted that not all of the pupils are engaging. (Telegraph 2020). The 16 pupils involved in my project are all those who replied to the request to participate (sent to 60). Some feedback I received was that pupils were under too much pressure to meet deadlines, and I was disappointed that they felt more under pressure than relaxed to be working at home. I am lucky that the 16 that agreed to participate gave me a wide range of abilities to conduct the research. The impact that these circumstances will have on pupils long term will not be known for a long time, but while we adjust to a 'new normal' we will, as my pupils maturely say, 'just have to get on with it'.

4. Diagnostic test, questionnaire and analysis of results - Before intervention

The Diagnostic test

Following the full review of literature I devised a diagnostic test containing the following questions. The test included similar questions worded in different ways, numeracy, and some provide multiple choice answers in order to provide pupils with cognitive conflict (Piaget 1963).

Misconceptions were found in the questions as follows (Appendix C) :

Question 1

Complete this number sentence $-17 - 5 =$

18.8 % of pupils answered -12 to this question, 6.3% answered 22 to this question - these answers imply that there is a misconception surrounding how to use the negative signs. The pupils either added the 5 to -17 or added both numbers.

Question 2

Work out $-2 + -5$

Whilst 68.8% of pupils answered this correctly, 31.2% did not understand what to do when a positive and negative sign are put together.

Question 3

What number is 3 more than -2.5

50% of pupils answered this question correctly whilst the rest of the group misunderstood by either taking 3 away from -2.5 or adding incorrectly.

Question 4

What is the value of B on a number line

Only 1 pupil misread the scale - this is not enough evidence to predict whether or not this is a misconception or a misreading.

Question 5

Which of the following statements are true when $n = -3$

- a. $n + 8 > -2n$ b) $n + 8 < -2$ c) $n + 8 = -2n$ d) not enough information

Only 4 of the group were correct with the answer to this question. It would be interesting to know if the $<>$ signs confused them, or if the rules of multiplying cause them an issue. This can be explored further with similar questions in the learning pack.

Question 6

The temperature is -5°C . The temperature rises by 5° . The new temperature is_____.

All but one of the group made an error with this question. The pupil emailed me to say they realised they had got this wrong - so I believe this to be a mistake not a misconception.

Question 7

The product of two numbers is -20 What could the two numbers be?

Only a quarter of the group were correct with this answer. The majority had a clear misunderstanding of the word product.

Question 8

Which symbols make the following sentence correct. $2_ - 7_ 0$

a. $>>$ b) $><$ c) $<>$ d) $<<$

Only one of the group was incorrect with this question, though hard to confirm, I believe this was a misunderstanding of $<>$.

Question 9

Jake is overdrawn by £20 in his bank. His salary of £548 is paid into his bank. His rent cost is £350. His mobile costs £45. His travel costs are £82. How much money is he left with in the bank after his wage goes in and his costs come out?

This question provided 5 different answers - 1 was correct, 4 were wrong, I believe the pupils found the mental addition and subtraction difficult in this question. More work on negative money values will help with any misconceptions.

Question 10

What is $5--3$?

44 % of the pupils answered - 8 to this question, showing a clear misconception of two negatives together. This is a common misconception and one that needs addressing head on with good methodology.

The Questionnaire - how the pupils like to learn before and during Lockdown

Due to the uniqueness of the situation that the pupils are currently faced with, I wanted to get an insight into their views of how they like to learn before and during this process of distance learning. Pupils like practical ways to learn, discussion and group work which is encouraging considering that the new curriculum reform in Wales encourages a more hands on involved approach to learning.

When questioned on what they liked about my own classroom lessons I was encouraged that the feedback suggested that the pupils like the visual powerpoints that I give them, my explanations and the range of activities I prepare. One pupil stated :

“Mrs Powell has a range of different teaching techniques, for example:

1. She encourages communication and group work.
2. Uses visuals and images to teach.
3. Ask students to present their ideas and methods.
4. Show and tell new concepts
5. Incorporate storytelling to make connections to real-world scenarios.”

This reinforced to me that pupils appreciate the different ways of learning I use in the classroom, and is why they have good focus in my lessons. It also shows that these are values that pupils do benefit from, and that I need to continue to provide even though we are not in an active school setting presently.

The pupils stated that they like using worksheets, but their favourite way of learning is by problem solving. Nearly all of the pupils stated that they preferred a verbal explanation if they made a mistake.

I found this feedback very useful, it provided confirmation that pupils were confidently engaging in activities I set, but it also gave me an insight into how they like to learn. As Alfred Mercier once said "What we learn with pleasure we never forget." Making work enjoyable is so important for engagement. The research also made me decide to present the unit of work to the pupils in a Slide format, as this was the aspect of my classroom lessons the pupils found most useful.

5. Intervention pack review

Each pupil was given the same intervention pack. Following the research I gathered from the pupils before its creation I knew I wanted to create a user friendly editable document that would not overwhelm any of them, as many had found too many separate pieces of work at once had caused them stress and anxiety.

Pupils had also given feedback that work had been given to them in subjects other than maths with no explanation and instruction and that they found this confusing. Due to the document being used not only for teaching, but to eradicate misconceptions, I included video clips and a slide presentation of working examples, making it an interactive step by step guide. I included click and drag activities, and editable worksheets to make it user friendly, and I also provided a mini investigation into temperature changes, as the pupils said they liked problem solving.

By exposing the pupils to misconceptions and providing true and false statements that the pupils had to think about, I was able to highlight the pupils that were experiencing cognitive conflict, and were having to challenge themselves to justify why misconceptions were misconceptions. Providing good literature for them to cross reference enabled them to correct misconceptions, and go on to answer similar questions correctly themselves. This proved a successful way to learn as pupils were battling with answers they thought were right but were actually wrong, and they had to find out why and correct themselves, in turn correcting their own misconception.

I ensured I provided activities that used AfL (Creating their own model, and correcting misconceptions), LNF (numeracy activities and written explanations of tasks and thinking) and Digital competency (All work required the use of ICT). I also took the five proficiencies into consideration by providing activities and explanations that gave - Conceptual understanding, Communicating with symbols, Fluency, Strategic Competence, Logical reasoning. This was mainly through a temperature activity, in which the pupils used a variety of skills to discover temperatures of five cities from given clues.

A pupil suggested that I could have included a focus on decimal numbers more in directed numbers within the work pack, which in hindsight I could have done. I originally chose not to do this as I was conscious about adhering to the main concept of directed numbers, and did not want to focus on decimal numbers. However I had already added one question including decimal numbers at the end to subtly see if adding a decimal question would confuse them or if they would take it in their stride.

When marking the work I was troubled to find a workbook containing many mistakes and obvious misconceptions. When questioned had they found the work difficult the pupil responded that they were confident on the topic, felt they did not need the reading material and videos, had no misconceptions and therefore had submitted the work the day it was set. I found myself spending a long time giving detailed responses to all of the mistakes, which took a long time to sort out. This was a difficult situation to deal with via email and messages. I had to devote a lot of time with this pupil, which is not an ideal situation to be in, and one of the down sides of distance learning. However the pupil took on board all of the advice given and worked through their mistakes and was able to identify their misconceptions. For one pupil this was fine, had this arisen with all 16 pupils it would've been unmanageable and time consuming. This is the down side to distance learning. Some pupils do not have parents who are able to sit and work things through with them, and teachers are not able to give attention

as they would in class. It will be interesting to see how other pupils have coped when they retake the diagnostic test.

I believe I produced a good working document that would give the pupils confidence and understanding on the topic, whilst addressing the misconceptions I noted in Diagnostic test 1. Following its completion I discovered that the pupils responded well to the document, and most participated in additional game links I posted for them on Google classroom. I am confident the intervention was sufficient to address any misconceptions, however the result of diagnostic test two will evidence this statement.

6. Diagnostic test 2, Questionnaire and analysis of results - Post intervention and Conclusion

Following the submission of the learning pack I gave the pupils the initial diagnostic test to take for a second time. Whilst an obvious improvement with the questions had been made not one pupil scored 100% in their second diagnostic test (Appendix D). I discovered pupils were still getting one particular question wrong:

Which of the following statements are true when $n = -3$

- c. $n+8 > -2n$ b) $n+8 < -2$ c) $n+8 = -2n$ d) *not enough information*

It is hard to prove whether this is due to a misconception in directed numbers or misuse of the greater than/less than functions therefore these results alone are not enough to draw a firm conclusion.

Looking at the questionnaire one pupil stated :

"I thought that two negatives made a positive, but one of the questions were like $-5--4$, and the answer was a negative. Am i wrong?" (sic)

which strongly indicates that this pupil still holds a misconception. However, whilst the pupils had the same amount of time to complete the work, I am unable to confirm the actual time each child spent on the work and what use each one made of the resources in the pack as I had no control over the exposure pupils had due to the learning being undertaken at home. This means I cannot prove whether this pupil misunderstood or was simply reluctant to make full use of the resource.

On further analysis of the pupils' work, I believe the learning pack I made was successful and the evidence indicates clear progression. My intervention was thorough, and contained resources all pupils could work with. Individual interaction would have provided a more thorough learning experience, however the results of the two diagnostic tests did show that even without actual teacher presence pupils were able to overcome the majority of initial misconceptions using only my detailed learning resource.

Further analysis of the questionnaire (Appendix E) proved that nearly all of the pupils believed they had resolved their misconceptions, with only one child thinking they had no misconceptions from the outset. All pupils felt progress had been made and that the resource had improved their knowledge.

The triangulation of this evidence allows me to conclude that when a child uses resources sensibly in a self disciplined manner, exposure to misconceptions in the learning of directed numbers **does** enable the majority of children to improve their understanding of the concepts of positive and negative numbers in a range of contexts. Using the learning pack pupils were able to identify a misconception, discuss it and correct it. Despite no pupil achieving 100% accuracy in their Diagnostic Test 2, when comparing the results from the initial test clear progress had been made. By being faced with misconceptions, pupils were able to confidently recognise and resolve them, which proved a good approach to battle their own cognitive conflicts. Pupils were able to overcome their own misconceptions without having the face to face teacher interaction that they are used to. This proves that exposing pupils to misconceptions with the use of a good learning pack can be a successful learning strategy.

7. References

- Barton, Craig. (2014). *Two thirds of children have not taken part in online lessons during lockdown, study finds*. Available: <http://www.mrbartonmaths.com/blog/article-misconception-two-minuses-make-plus/>. Last accessed 5th May 2020.
- Chambers, Paul & Timlin, Robert. (2008) *Teaching Mathematics in the Secondary School*. London: SAGE. p104-108.
- Clements, D. H. & McMillen, S. (1996) Rethinking 'concrete' manipulatives, *Teaching Children Mathematics*, 2(5), pp. 270–279.
- McLeod, Saul McLeod. (2019). *The Zone of Proximal Development and Scaffolding*. Available: <https://www.simplypsychology.org/Zone-of-Proximal-Development.html>. Last accessed 5th May 2020.
- Makonye, Judah Paul & Fakude, Josiah. (2016). A Study of Errors and Misconceptions in the Learning of Addition and Subtraction of Directed Numbers. *SAGE Open*. October-December 2016: 1–10 (1), p1-2.
- Morrison, Nick. (2020). *Lockdown Will Only Widen The Gap Between Rich And Poor Students*. Available: <https://www.forbes.com/sites/nickmorrison/2020/04/09/lockdown-will-only-widen-the-gap-between-rich-and-poor-students/#29869c2754ad>. Last accessed 5th May 2020.
- Olivier, A. (1989). *Handling pupils misconceptions*. Stellenbosch, South Africa: University of Stellenbosch
- Piaget, J. & Inhelder, B. (1967). *The Child's Conception of Space*. See especially "Systems of Reference and Horizontal-Vertical Coordinates." p. 375-418. New York: W. W. Norton & Co.
- Polya, G. (1945). *How to solve it; a new aspect of mathematical method*. Princeton University Press.
- Skemp, R. R. (1987). *The psychology of learning mathematics*. London, England: Psychology Press.
- Tanner, H. & Jones, S.,(2000) *Becoming a Successful Teacher of Mathematics*
- Turner, Camilla. (2020). *Two thirds of children have not taken part in online lessons during lockdown, study finds*. Available: <https://www.telegraph.co.uk/news/2020/04/19/two-thirds-children-have-not-taken-part-online-lessons-lockdown/>. Last accessed 5th May 2020.
- unknown. (2020). *Coronavirus: Laptops and 4G internet offered to school pupils*. Available: <https://www.bbc.co.uk/news/uk-wales-politics-52478688>. Last accessed 5th May 2020.
- unknown. (2020). *Alfred Mercier*. Available: <https://www.quotes.net/authors/Alfred+Mercier>. Last accessed 10th May 2020.
- Welsh Government. (2019). 3. *Principles of progression*. Available: <https://hwb.gov.wales/curriculum-for-wales/mathematics-and-numeracy/principles-of-progression/>. Last accessed 5th May 2020.
- Young, Colleen. (2019). *Quote*. Available: <https://diagnosticquestions.com/>. Last accessed 5th May 2020.

8. Appendices

Appendix A

Questionnaire One

In the Classroom

What methods of teaching mathematics does Mrs Powell use in the classroom that you like and why?

What activities in Maths benefit you the best?

How do you like to be corrected if you get something wrong?

Distance Learning

Mrs Powell has set many activities - which has been the most beneficial to you so far

We are only able to communicate via email and Classroom - has this had an impact on your learning?

Again thinking of the work Mrs Powell has set you, what could be done to make your learning better.

What activities would you like to see more of when distant learning?

If you are finding something hard to understand - what do you do?

How do you feel about maths and distance learning?

Appendix B

Questionnaire Two

Learning Pack feedback

Before using the learning pack how confident were you with directed numbers? 1- not confident 5 - very confident

Did you like this learning pack? Please give a reason

Which was your favourite part?

Were there any parts you would change?

Has this pack helped you sort out any misconceptions you may have had?

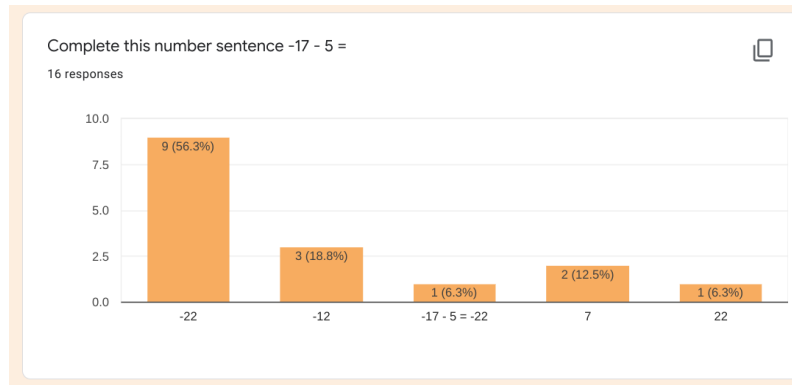
What is the most important thing this pack taught you regarding directed numbers?

After using the learning pack how confident are you with directed numbers? 1- not confident 5 - very confident

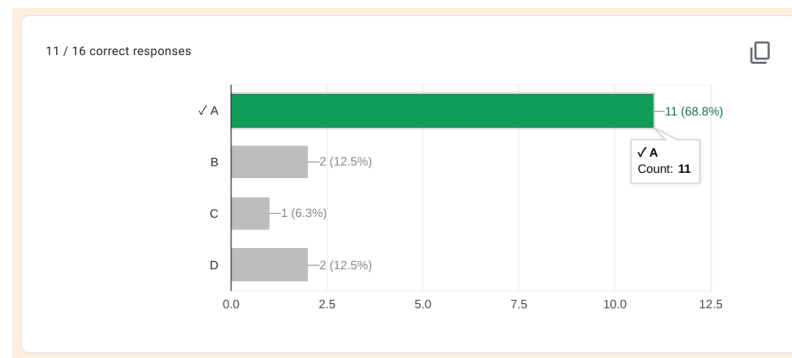
Has this resource made you feel more confident with maths and distance learning?

Appendix C - Diagnostic Test 1 results

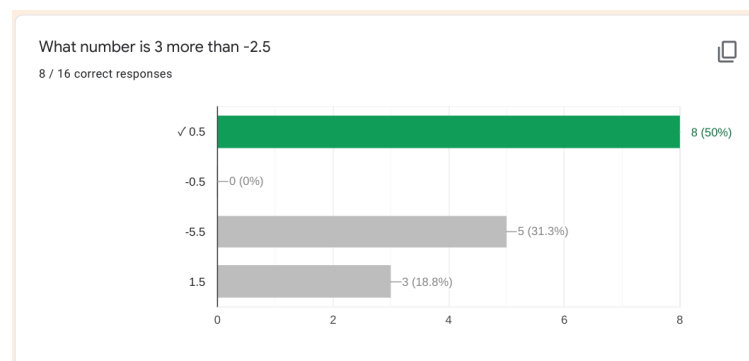
Question one results



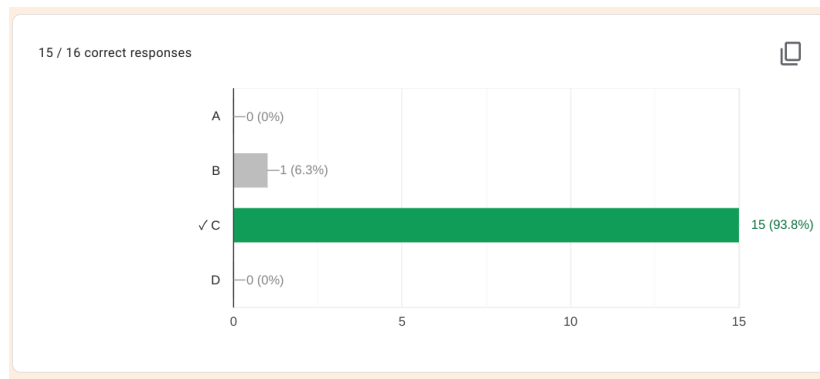
Question two results



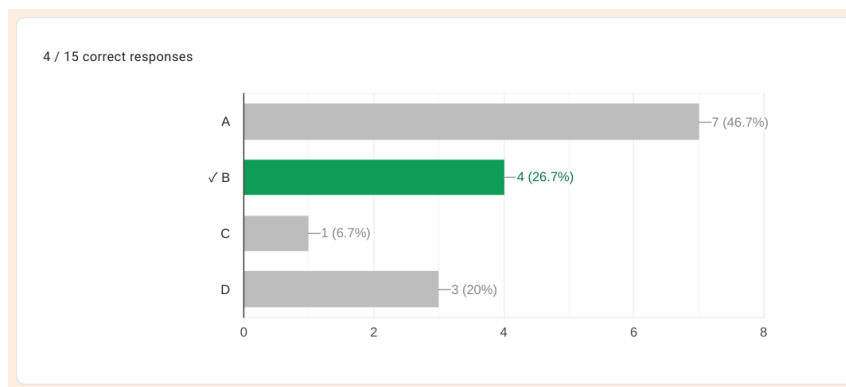
Question three results



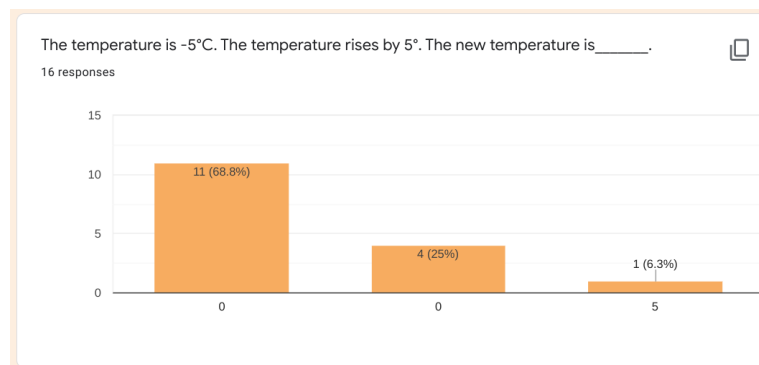
Question 4 results



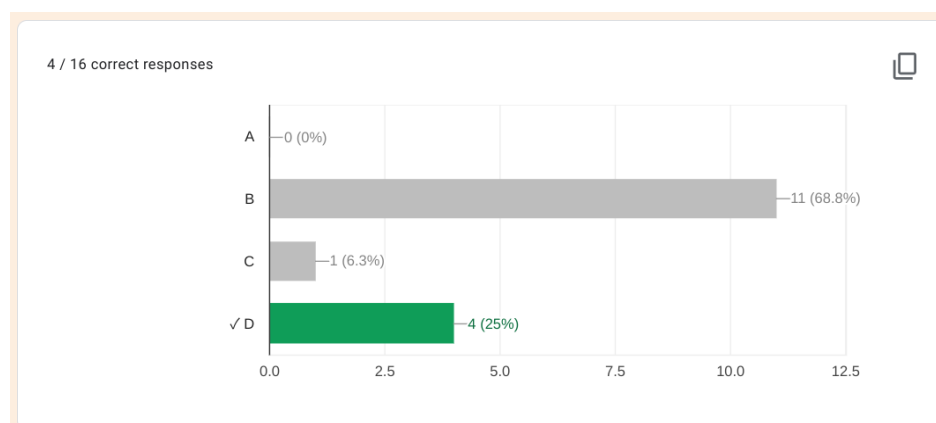
Question 5 Results



Question 6 results

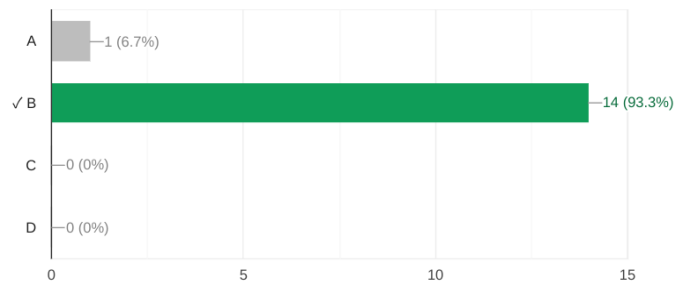


Question 7 results



Question 8 results

14 / 15 correct responses

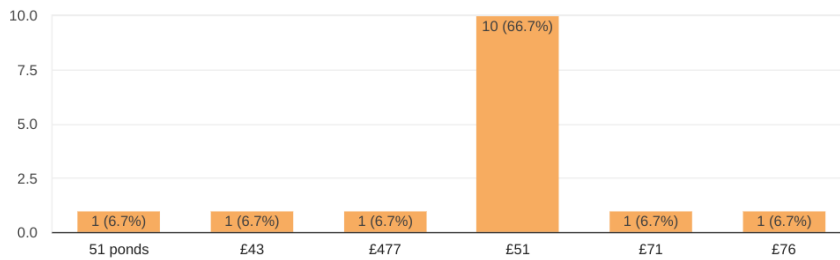


Question 9 results

Jake is overdrawn by £20 in his bank. His salary of £548 is paid into his bank. His rent cost is £350. His mobile costs £45. His travel costs are £82. How much money is he left with in the bank after his wage goes in and his costs come out?

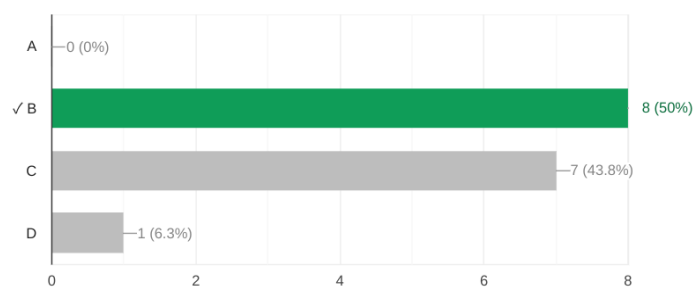


15 responses



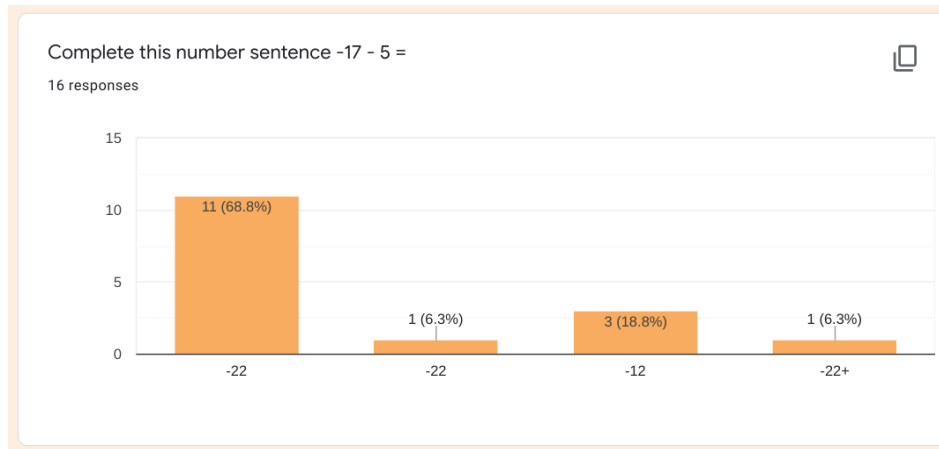
Question 10 results

8 / 16 correct responses

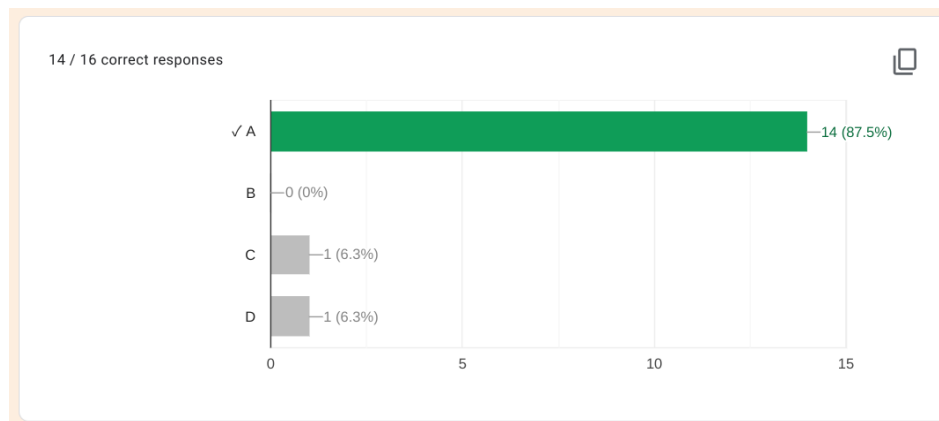


Appendix D - Diagnostic Test 2 Results

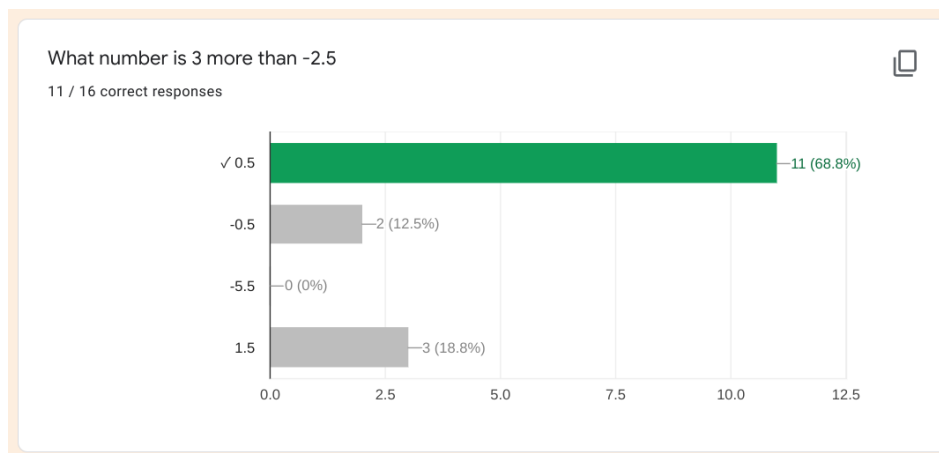
Question one results



Question Two results

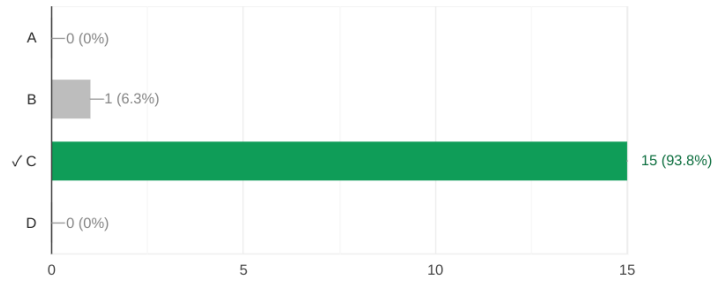


Question Three results



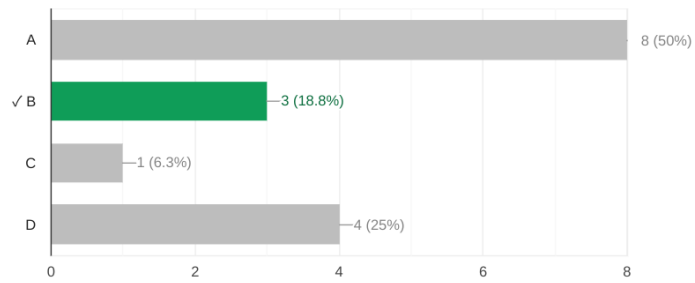
Question Four results

15 / 16 correct responses



Question Five results

3 / 16 correct responses

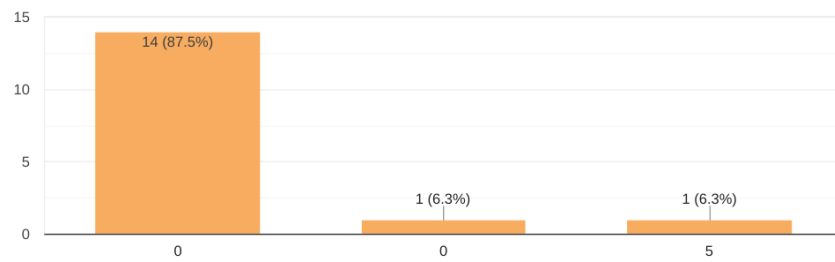


Question Six results

The temperature is -5°C . The temperature rises by 5° . The new temperature is _____.

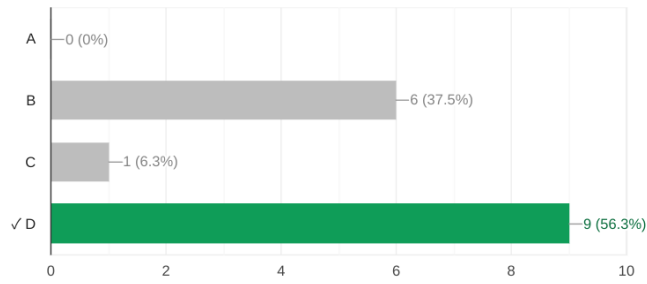


16 responses



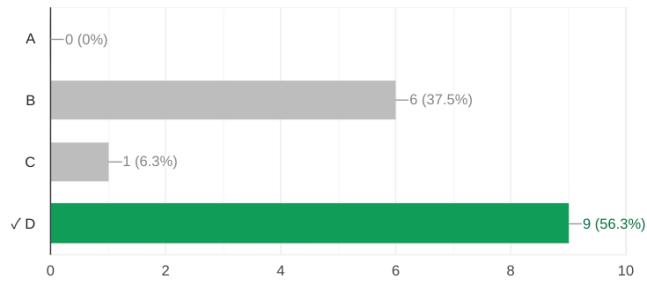
Question Seven results

9 / 16 correct responses



Question Eight results

9 / 16 correct responses

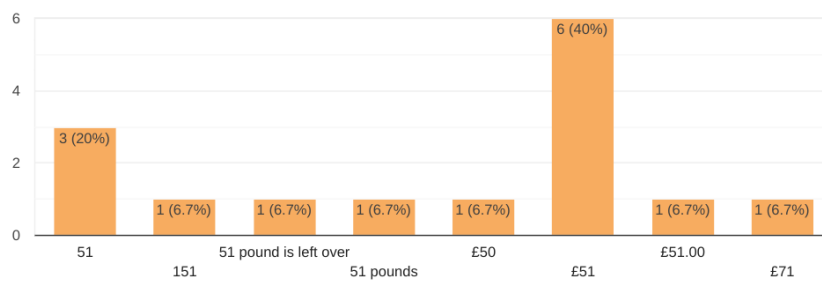


Question Nine results

Jake is overdrawn by £20 in his bank. His salary of £548 is paid into his bank. His rent cost is £350. His mobile costs £45. His travel costs are £82. How much money is he left with in the bank after his wage goes in and his costs come out?

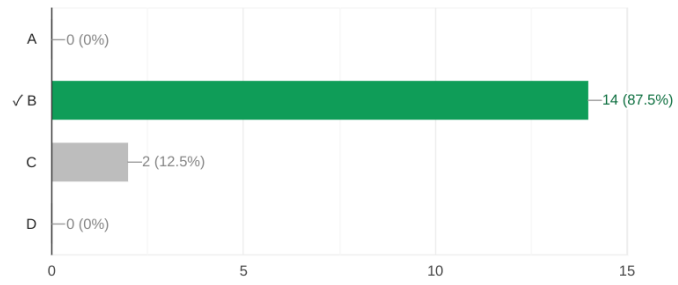


15 responses



Question Ten results

14 / 16 correct responses

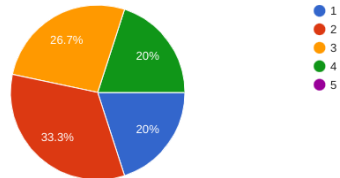


Appendix E - Questionnaire responses

Before using the learning pack how confident were you with directed numbers? 1- not confident 5 - very confident



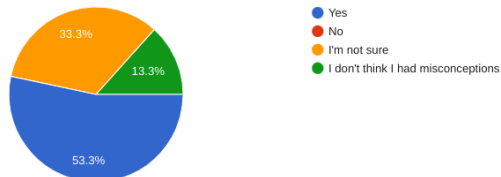
15 responses



Has this pack helped you sort out any misconceptions you may have had?



15 responses



After using the learning pack how confident are you with directed numbers? 1- not confident 5 - very confident



15 responses

