



ASSIGNMENT DETAILS AND FEEDBACK

SOUTH WEST WALES CENTRE FOR TEACHER EDUCATION

Sections marked with * should be completed by module lead

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Researching the Impact of a Carefully Designed Scheme of Work on Pupils' Use of Misconceptions in Algebra and Associated Assessment for Learning.

Gabrielle Jones

Introduction

School X is a English medium community Secondary School in the South Wales Valley with nearly 1,700 pupils enrolled, all of whom are aged eleven to eighteen years old. The latest inspection report states that around 23.3% of pupils are eligible for free school meals (FSM), a figure which has been consistent for the three years prior to inspection, and 24% of pupils are on the school's additional learning needs (ALN) register (Estyn, 2016). The School is categorized as an overall "Good" school with areas of excellence throughout the strands (Estyn, 2016) and falls into the Yellow Support Category with regards to the National School Categorisation System (Welsh Government, 2018). With around 41% of pupils living in the 20% most deprived areas in Wales, School X is committed to providing excellence for all, presenting all pupils of all backgrounds with the opportunity to succeed.

My research targets a top band (Stage 3) Year 8 class consisting of fourteen learners, named 8 North 7 who are considered to be the '*bottom class of the top band*'. Although the class is in the top band, due to both Literacy and Numeracy factors, Mathematical ability overall is currently quite weak thus the class are currently following and studying the lower band (Stage 2) scheme of work.

My desire is to explore the misconceptions made in algebra sparked from the stigma associated with such topic. Algebra is often perceived as being a difficult topic and something which a majority of pupils will openly say they 'hate'. Pupils fail to appreciate the usefulness of algebra and how such topic can be explored with great fascination (French, 2002).

I want to help combat the stigma of algebra and research the impact made on pupils learning through effective teaching which carefully considers possible misconceptions.

Literature Review

Current literature and research highlights that misconceptions appear in all areas of Mathematics from calculating problems involving decimals to understanding algebra (Steinle, 2004; Wagner, 1989). This has become apparent to me whilst teaching at both my placement schools during my teacher training year. Misconceptions appear in every topic of Maths which can range from Primary School through to Secondary School (Ryan and Williams, 2007). From experience, it has been interesting for me to see how pupils can justify their misconceptions and give reasons as to

why they think that their method or ideas are correct. Errors are often made with a logical justification to support them and in order to develop pupils learning it is valuable that students investigate their own errors (Ryan and Williams, 2007). Pupils often apply rules and patterns from one area of Mathematics to another which simply does not work (Askew and Williams, 1995). An example of this can be given when multiplying by ten. Pupils are taught a rule that when you multiply a number by ten you simply add a “0” on the end of the number. This can be true for many situations however when pupils then move on to multiplying decimals by ten this rule does not hold. Of course, inventing these rules and quick methods are useful for many topics in Mathematics to avoid cognitive overload (Sweller, 1994), but we must not solely focus on this instrumental style of teaching but focus more on a relational style of teaching (Skemp, 1976). I believe through pupils primarily having a relational understanding of a certain topic, which is then supported by instrumental understanding or these “quick rules”, then this would lead to misconceptions occurring less.

In order to become an effective teacher Tanner and Jones (2000) suggests that we, as teachers, must address these misconceptions in lessons and plan for them. It could be suggested that these misconceptions occur due to a lack of effective pedagogy within the education system, not putting the blame solely on teachers but the system itself (Ryan and Williams, 2007). However it is undeniable that teachers have a duty to highlight and combat these misconceptions during lessons and is an important element to consider when planning lessons:

“misconceptions will remain hidden unless the teacher makes specific efforts to uncover them” (Askew & Williams, 1995).

This is supported by the Qualified Teaching Standards (QTS) which includes standards such as *Standard Strand S3.1 – Teaching, planning, expectations and targets* (Welsh Government, 2009).

My research focuses on the misconceptions made within the topic of algebra, a fundamental part of Mathematics. Research states that there are two reasons as to why algebra is part of the curriculum. The first is for its usefulness in the real world and the second is that algebra is an interesting topic of Mathematics which provides the opportunity for pupils to develop many skills (French, 2002). Algebra develops a plethora of personal skills such as problem solving, explanation and proof. It can also be considered as a necessity for future employment within fields such as Engineering and Science. The inclusion of algebra within the curriculum allows students to appreciate the foundations of algebra while also providing students the opportunity to explore in detail the joys of Mathematics, especially at A-Level. Having said that, not all young people will appreciate the usefulness of algebra in later life as only a minority will want to go into careers which involve such Mathematical applications. Due to such reasons stated above, algebra can

sometimes be perceived as quite an abstract topic and may be the reason as to why there are endless misconceptions which appear during the teaching and learning of such topic.

In order to help research the misconceptions made in algebra within my Year 8 class, I will use a pre and post-test. This diagnostic test will consist of ten questions and will be used to inform my planning when trying to help combat the misconceptions made in algebra. As Cockcroft (1982) states, “mathematics is a difficult subject to teach and learn” thus it is important that teachers address the common misconceptions made with the aim of greater success and enjoyment with the learning of algebra. Through research and literature readings, I was able to explore the common misconceptions made and create my diagnostic test.

Misconceptions arise from the initial point of learning algebra. The most common misconceptions occur from the lack of understanding of the letter itself. Multiple literature states that the different interpretations that students give to letters can be split into six categories (Wagner, 1989; French, 2002):

- (1) Letter evaluated
- (2) Letter not used
- (3) Letter as an object
- (4) Letter as a specific unknown
- (5) Letter as a generalised number
- (6) Letter as a variable

I will now go on to touch upon some of the categories mentioned above and discuss how such research has informed the questions within my diagnostic testing.

In the first case, (1) letter evaluated, students may allocate the letter a numerical value from the beginning. For example students will immediately recognise that $a = 5$ when given the equation $a + 2 = 7$ because they can instantly identify that $5 + 2 = 7$. In this case no calculation or rearrangement is needed because the students can instantly identify the correct value of a straight away. Often when given simple problems for solving equations students can intuitively solve them just by “spotting” the answer. However when the problem then becomes more complex and requires understanding pupils become confused as they cannot identify the answer straight away (Askew and William, 1995).

Another method which can lead to endless misconceptions is the third case where the letter is thought of as an object. I have observed many lessons where students use the idea that the letter is shorthand for an object starting with that letter, rather than representing a number. For example a stands for apple, b is for banana, c for cat and so on, often referred to as the teaching strategy ‘Fruit Salad Algebra’ (Tennant and Colloff, 2014). Inconveniently using this idea will work for some

situations when simplifying algebraic expressions and can be useful to a teacher when explaining collecting like terms. Let us take $3a + 4a$ as a prime example of such case. Some students would associate the letter a with apple, thus if we have 3 apples and add on another 4 apples we would get the answer of 7 apples which would give us the final answer of $7a$. In a minority of cases students may actually write the final answer of “7 apples” as that is the object that they have assigned to the letter and they are confident that they have got the correct answer. Within my diagnostic test I wanted to see if the majority of pupils would coincidentally obtain a correct answer to such misconception and therefore decided to base question 1 on this.

However using this thought process is not at all useful when pupils are then given expressions to simplify such as $3a + 4a + 2$. In this case, by associating letters with objects pupils would become confused as to what the 2 represents as it has no letter attached. As French (2002) explains, pupils quickly react with “2 what?” when given such expression to simplify. A common incorrect answer given for this question would be $9a$. Pupils don’t comprehend that an answer of $7a + 2$ is correct thus they add all the terms together. This touches upon the fact that some pupils have a fixed idea on what an answer should look like and that students must change their expectation that an answer can only consist of numbers (Wagner, 1989).

Question 9 of my diagnostic test was introduced to challenge the pupils understanding of what the letters actually mean. Teaching of algebra often refers to the letter as representing any number, but this explanation of the letters can cause many errors to be made (Ryan and Williams, 2007). Let us look at Question 9 of the diagnostic test where pupils are asked to calculate the perimeter of the rectangle. This is something which this particular class would successfully complete with ease if the lengths of the sides were given to them in numerical values. However, now they are faced with a simple question but with the lengths of the sides being letters. Questions like such are introduced in the early stages of learning algebra however their past experiences cannot easily be related to the algebra which they are exposed to in Secondary School (Kieran, 1989). Pupils are often taught that letters can represent any number so a common misconception would be for the pupils to choose any number for a and any number for b and then calculate the perimeter as usual. This relates back to the idea of pupils having a fixed idea on what an answer must look like. Pupils know the method used to calculate the perimeter of such shape but believe that the answer must be a numerical value when in this case the answer is not. My teaching needs to develop students’ algebraic thinking by exposing them to familiar questions but in a different context. This develops their problem solving skills and gives them a situation that they can relate to.

Another misconception made which could be highlighted throughout all of the questions within my diagnostic test is that students make a connection between letters and their position/order in the alphabet. Although letters can represent any value, students will often argue that $a = 1, b = 2, c = 3$ and so on (Ryan and Williams, 2007). I decided to include a variety of simplifying questions

within my diagnostic test in order to see the different answers pupils would give. Question 1 (Appendix A) was introduced initially to see if pupils would be successful in assigning the letters to an object and obtaining the correct answer. After some thought, I then realised that numerous possible answers could appear, such as assigning the value 1 with the letter a therefore giving an answer of 4. I also wondered if pupils would then use this value of 4 and find the letter which was 4th in the alphabet which would then give an answer of d . Due to this question being one in which I thought the majority of pupils would be successful on, I decided to include Question 6. Here I expected pupils to give final answer of 9 as if c represents the number 3 in the alphabet then $3 \times 3 = 9$.

This question could cause confusion with not only the variable but also the multiplication symbol involved. Within the topic of algebra the most common variable used is the letter x . When beginning to teach algebra it was extremely important for me that students could distinguish the difference between the multiply symbol $\times$ and the variable x . I would constantly remind pupils to show the difference in their workings by using a straight x for multiply and a curly x for the letter. Ideally, it would make sense to shy away from using the variable x when studying algebra, however it is fundamental that we as teachers familiarise students with such problems especially as nowadays students are awarded marks in the new WJEC Numeracy Maths exam for the way in which they explain and communicate their answer. These marks are referred to as the OCW Marks – Organisation, communication and accuracy of writing. Ryan and Williams (2007) support the idea of using variables other than x within algebra as students may interpret $6x$ as 6 times or 6 multiplied which could lead to some confusion. Indeed, this is the process involved with such expressions however it is difficult for us as teachers to explain such concept. As a result, the idea of the invisible multiplication sign was introduced and is something which I have adopted in my teaching. This highlights the important role we as teachers have in order to iron out these misconceptions and make students aware of such problems they may occur.

In algebra a lot of confusion stems from the 'invisible' multiplication sign and understandably so. French (2002) explains that the problems here are related to juxtaposition and how we explain that when two symbols, say 4 and y , are next to each other becomes $4y$. Through my teaching, I had to ensure that pupils all clearly understood that " $4y$ " means " $4 \times y$ " and would include a question relating to this on every single one of my starters. By constantly addressing this misconception at the start of every lesson I would use this repetitive reinforcement to ensure that students did not make this error in future. I was aware of the importance of addressing such misconception before reading literature, however further reading into this topic allowed me to realise that confusion stems from many situations where letters are then used to represent units (French, 2002). For example, 2 grams is written as $2g$ and 4 kilograms is written as $4kg$.

I decided to not include any questions involving units in my teaching or diagnostic testing as I

wanted to focus of the foundations of algebra and the concept of the “invisible” multiplication sign. After research, I decided to assess such misconception through Question 8, where students had to substitute in the value $x = 3$ into the expression $4x - 5$. Through reading I expect to see the majority of pupils giving a final answer of 38. This is because they may have no understanding of the multiplication involved and simply replace the x with 3, giving them $43 - 5 = 38$. Question 6 uses the multiplication sign thus highlights more the misconception of the answer $c \times c = 2c$ rather than c^2 . My teaching strategy to address such problem would be to recap the topic of square numbers which all the class are familiar with. Building on this we would then introduce the idea of square letters and look at questions involving this. Due to the class ability, I chose not to go into detail regarding index notation and the misconceptions which arise as I feel that it was not necessary for this particular class and the scheme of work which they are following.

Question 5 of my diagnostic test relates to the understanding of certain algebra facts and patterns, for example $a + b = b + a$. These facts are a requirement to be taught in the scheme of work thus it was important that learners could understand and prove such relationships. Usikin (1988) describes the natural nature of thinking of variables as pattern generalizers, which allows us to describe relationships between numbers mathematically using algebra. Algebra is an effective tool of expressing generality which can be used to solve problems (French, 2002), however as effective teachers we must ensure that students are not bombarded with a set of rules without reason, which follows an instrumental style of teaching (Skemp, 1976). Ideally for this question, students would substitute in values for a and b to see if the statement was true or false. When using true or false questions there is the chance that students could coincidentally obtain the correct answer, thus I was interested to see if pupils used any workings when answering this question.

Through research it has been confirmed that there are numerous misconceptions relating to algebra. The way in which algebra is introduced to students is crucial for success and the teacher must ensure that a style of teaching is used which constantly exposes and discusses such misconceptions (Askew and William, 1995; Tanner and Jones 2000).

School Policy, Practice and Diagnostic Test

In order to begin my research it was necessary that I studied the relevant scheme of work beforehand (Appendix B). By taking time to study the scheme of work and look at the work previously covered with their class teacher I was able to create a success criteria for this topic and begin the planning phase for my research, which would cover four lessons.

During my time at School X, I have also found that working collaboratively with department staff has had a huge impact on my teaching. Through professional dialogue I have been able to understand how the department currently deal with misconceptions and how the Numeracy

Starters are used to reinforce and discuss potential errors made. Discussing past experiences of teachers has also been beneficial to my planning, as I have been able to further my understanding of effective teaching strategies and been able to learn what works well with different classes for this particular school.

Alongside teaching, a main factor to consider when planning was assessment and feedback, in particular Assessment for Learning (AfL). School X is currently piloting a new departmental policy in Maths this year where teachers do not mark books outside of lessons. As a result, it is extremely important for me that AfL strategies are used effectively in the classroom and that quality feedback is given during lesson time. Assessment has many purposes for teachers, such as to analyse how a pupil is learning, to discover what a pupil knows/or can do and to evaluate the success of the teachers own teaching (Tanner and Jones, 2000).

In order to assess the impact made when addressing misconceptions through my teaching, I have decided to use a pre and post-test, a form of formative assessment (Appendix A). As mentioned above, the test will consist of ten questions which are based on the literature which I have studied. The pre-test will act as a diagnostic tool which would allow me to assess pupil's prior knowledge of algebra and highlight the misconceptions which pupils already have. The information gained from the pre-test will then largely drive and inform my planning of lessons, with the fundamental aim of overcoming misconceptions made.

Once the four lessons of teaching are completed, pupils will then complete the same test again, this time acting as a post-test. Through completing the pre and post-test, I will be able to compare the scores of the two tests to see the impact in which my teaching has had. It is expected that during the four lessons misconceptions have been addressed, discussed and acted upon therefore creating both individual and whole class success on the scores in the post-test.

Methodology and Ethics

Literature confirms that there are many methods in which research can be explored, such as observation, interview or questionnaire (Hopkins, 2002; Cohen and Manion and Morrison, 2011). I am now going to explore in detail the literature regarding my chosen methodologies used during my research, looking at both the benefits and limitations.

Firstly, the method I have chosen in order to assess the impact of my teaching is through the use of a pre and post-test. Pre and post-testing is an effective way to not only measure pupil success but to also assess the impact and effectiveness of teaching (Tanner and Jones, 2000). The pre-test designed for my research is of a diagnostic nature and will allow me to assess pupil's base-line knowledge of algebra and the misconceptions that they have before I start teaching. I will study the results from the pre-test qualitatively with regards to the pupils' answers and use this to inform my planning for the teaching of lessons. The post-test will then be taken at the end of the

four lessons of teaching and the actual results from the pre and post tests will be compared quantitatively. The design and conduction of the pre and post-tests was crucial to gaining useful and valid data. When designing and conducting my test I ensured that every student would sit the same test no matter what level descriptor they are currently working at and that the pre and post-test did not differ in content, meaning both tests were exactly the same. By following such rules, this instilled an element of fairness with regards to my classroom research and reliability with regards to the results and data. However, it may be argued that repetition of the same test is not an effective way of evaluating success. As Newton (1999) states, if we use pre and post testing to develop our understanding of how students learn and not solely use it as a tool to measure the number of correct responses, then pre and post testing is an effective tool of research. An everyday practice used by successful teachers is assessing pupil's prior knowledge, teaching to address these misconceptions and then assessing pupils understanding whether it be through pre and post testing or other methods. We often refer to this cyclic nature of teaching as a 'learning journey'.

In order to monitor the effectiveness of my interventions, which were put into place to help address the misconceptions made in algebra, a range of AfL strategies were used. Assessment has many purposes but above all assessment is used as a form of communication between teacher and pupil; teachers receive feedback on their teaching and pupils receive feedback on their learning (Tanner and Jones, 2000). Research by Black and William (1998), has proved that increasing use of formative assessment has a significant positive impact on pupils learning. AfL strategies used in my lessons included a range of effective questioning, the use of the Red, Amber, Green pages in pupils' planners and the "Think, Pair, Share" strategy. In the Topic Pack (Appendix C), there is an example of a lesson's resources, this particular lesson being Simplifying Algebraic Expressions involving multiplication. Different AfL strategies have been clearly highlighted in the lesson plan along with the resources used.

As well as being a teacher, I also have the dual role of a researcher. By being both I have a responsibility to ensure that when conducting research, the Ethical Guidelines for Educational Research set out by the British Educational Research Association (BERA) are followed (BERA, 2011). Guidelines include ensuring the confidentiality and anonymity of the school, pupils and staff and keeping data confidential. As both a teacher and researcher, I am responsible for ensuring that pupils feel safe and comfortable within my classroom environment (Campbell and Groundwater-Smith, 2007), thus I am accountable for ensuring all names of participants are anonymised in the assignment and at all times during any discussion which may take place with the school mentor and university tutor. It was also extremely important for me that emphasis was made that the test was used for my benefit and it would in no way be recorded by the school or stored on any school monitoring system. I ensured that pupils were aware that they had the right to

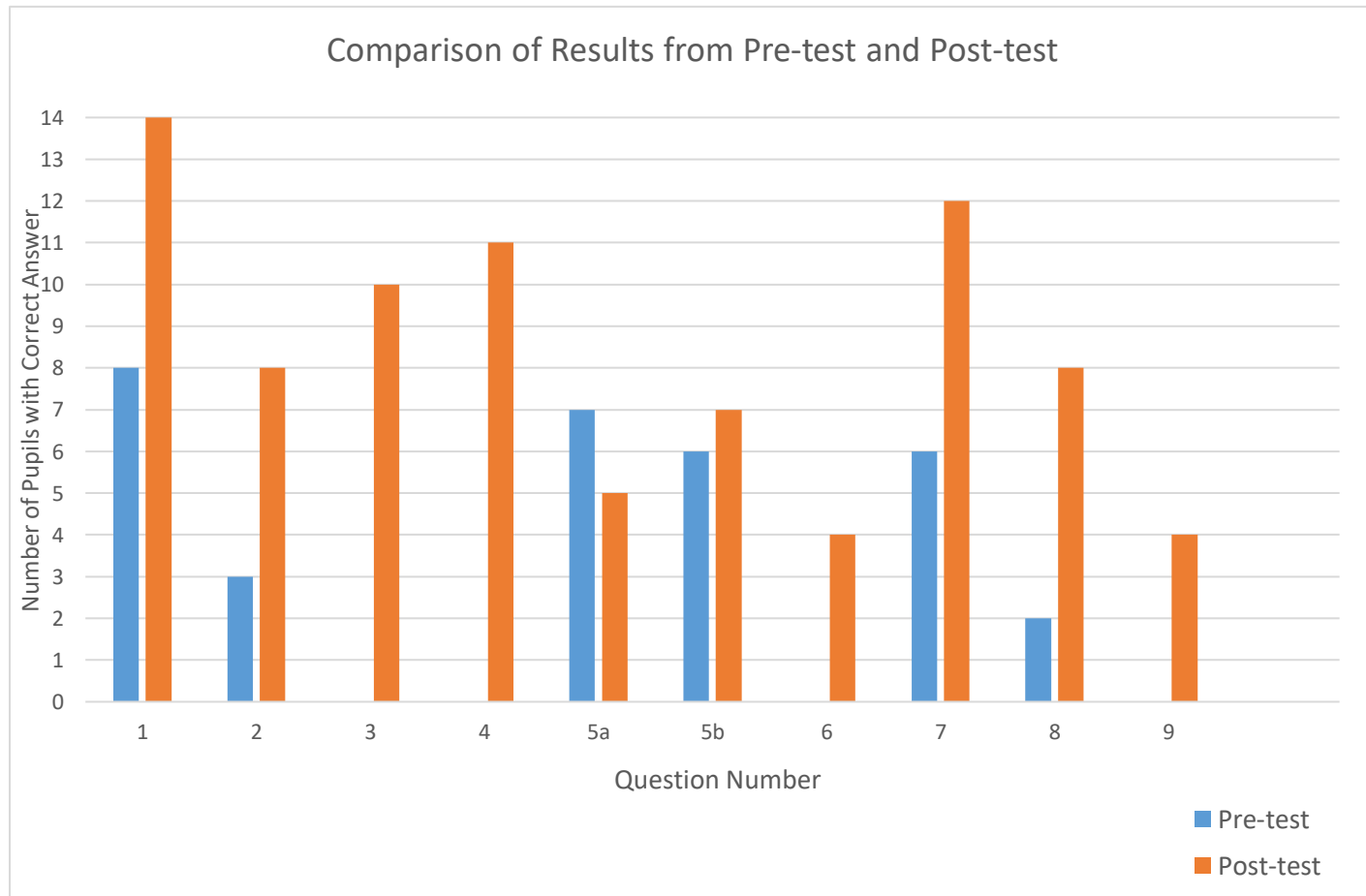
say no to being included in the research or that they could withdraw at any time if they so wish. In order for me to ensure that pupils wishing to participate in the research were fully aware of their involvement, I got the pupils to sign a consent form (Appendix D). School is a place where students must conform and follow rules but it was important for me that students understood that their participation was totally voluntary (Campbell and Groundwater-Smith, 2007).

In order to start the process of collecting data for my research, an ethics form had to be completed and approved by the Faculty Ethics committee. By doing so I followed University procedure accordingly and ensured that I was fully aware of my dual role as both a participant and researcher. This was in accordance with the BERA guidelines set out to ensure that my research met all ethical criteria.

Evaluation

I am now going to study in detail the answers given from both the pre and post-test (Appendix A) to evaluate the impact of my teaching with regards to addressing misconceptions. I will look at this question by question and discuss answers given as well as the teaching strategies used to address such mathematical ideas and concepts.

To represent the data from both tests I have created a comparative bar chart (displayed below) which clearly represents the data collected for both formative assessments.



Question 1

As a whole class, on both tests question 1 was the question that was best answered with 8 out of 14 pupils answering the question correctly on the pre-test and 14 out of 14 pupils answering correctly on the post-test. Collecting like terms was the first area of algebra studied by the class and was introduced in a way in which pupils could relate to. I find that pupils are always questioning “when will I use this in real life” and it was important for me that I introduced algebra in a real life context where pupils could see that applications of algebra are used in day to day life outside of the classroom. French (2002) supports the idea of providing a context to Mathematics and relating problems and ideas to something familiar with the student. I introduced the idea of collecting like terms by displaying a shopping list on the board with items appearing more than once. Through effective questioning I then asked the class if there was an easier way we could write this list and they all understood that we could group the same items. Here I adopted the strategy of associating a letter with an object (French, 2002). When studying the misconceptions made in the pre-test answers I could see that a large proportion of the class had an answer of “d” for question 1, relating the letter with the alphabet which was an expected misconception (Ryan and Williams, 2007). Although literature states that so called “fruit salad algebra” may cause misconceptions for pupils when learning algebra, I believe that it was necessary for this particular class to grasp the concept of simplifying in such a way. All pupils were successful in this particular question in the post-test thus a significant impact was made.

Question 2

For this particular question, the results given by pupils was something which I did not expect from my literature review. This question was created in order to build upon the idea of simplifying expressions in question 1, however this time the operation involved was subtraction and pupils had to identify that $5y - y$ means $5y - 1y$. A popular error made by students in both the pre and post-test is that they would simply get rid of the y term which leaves them with an answer of 5. Of course, we can understand the thought process of this incorrect answer and is something which I did not thoroughly consider in my planning. Throughout my lesson, questions involving subtraction were studied however I did not expose the pupils to such misconception which the majority made. In the pre-test 3 out of 14 pupils were successful in obtaining a correct answer and a further 5 in the post-test. I think that greater impact could have been made in this question if emphasis was made on the misconception during lesson and I believe that it is a misconception which was overlooked on my behalf.

Question 3 and 4

Notable success was made on both simplifying questions which involved more than one variable, with no one obtaining a correct answer in the pre-test. The results from question 3 are interesting as many of the pupils who failed to answer question 2 correctly obtained the correct answer for question 3. Question 3 was taught through going through 2 examples as a class followed by a Collecting Like Terms Dominos activity. Once pupils successfully matched their dominos and checked with myself or the class teacher, they then copied these into their books. Pupils learn best through interactive and engaging lessons and their enjoyment of working in pairs for such task could be a factor to the success of this question.

Question 4 challenged pupils understanding of algebra and was introduced to test this. A pedagogical approach was used within my lesson where I played the role of devil's advocate (Davis, 2013). Through the example of $5m + 2c$ I would proceed to explain that the answer would be $7mc$, a misconception almost all pupils made on the pre-test. Pupils quickly and eagerly corrected my error and were able to give justification as to why I was incorrect. I have found that pupils really do enjoy correcting me as a teacher and has been a teaching strategy used a multiple occasions in my lesson when suitable. By using such strategy we must ensure that unnecessary confusion isn't created and that students aren't copying down the incorrect answer being made in their books. Although few risks are associated with such strategy, I have found it successful with this particular class and the results from the post-test highlight this.

Question 5

Question 5 was split into two sub questions and was the only question in which pupils results lowered from the pre-test. The question required students to state whether the statement given was true or false with no justification. The danger with using true or false questions is that results are largely impacted through an element of guessing. Due to there being no requirement for pupils to explain their answer, many pupils would openly admit that their answer was just a guess. This was highlighted in the inconsistency of both class results and individual results. 3 pupils who obtained a correct answer to question 5a in the pre-test obtained an incorrect answer in the post-test and the 2 pupils who got both questions 5a and 5b correct did not get any correct in the post-test. In hindsight, I believe that this question was not sufficient enough in neither measuring the impact made in the teaching nor assessing the pupil's progress in lessons and could be argued that this particular question was too ambiguous for learners. One student in particular requested explanation of the answer to question 5a, as he explained that his thought process was if you have apples and bananas then this is the same as having bananas and apples. This highlights the danger of assigning letters to objects as he did not comprehend that for this particular question the letters represent numerical values. I believe that the design of such question was not clear to pupils. If I were to revisit this question I would ask for justification to be given as well as an answer of true or false.

Question 6 and 7

As a requirement to meet on the scheme of work, pupils are expected to simplify expressions using multiplication. Through the study of literature all misconceptions which appeared in pupils answers were expected and thus it was paramount that my planning of lessons addressed such. My resources for this lesson (Appendix C) were highly influenced through the misconceptions made by pupils. When teaching I found it extremely useful to add comments that only I could see on my PowerPoint slides to help remind me of areas I needed to address with greater emphasis. I was pleasing to see that throughout the lessons pupils would often interrupt the lesson by saying “I got that wrong on the test”. It is of high importance that pupils can not only see that they have made an error but they understand why they have made the error and how to rectify their answer, it is not only about pupils knowing whether they are right or wrong (Ryan and Williams, 2007). The number of correct answers for Question 7 doubled in the post-test and I feel that this represents the success of the lesson taught and the teaching strategies used.

Question 8

For this particular class, substitution involved only working with positive whole numbers. In the pre-test only 2 pupils correctly answered this question with the main misconception being the lack of understanding of $4x$ meaning $4 \times x$. Of course when researching the misconceptions made in algebra the concept of multiplication proved to be a main problem with research highlighting many errors could possibly occur (French, 2002; Wagner, 1989). Throughout my teaching, emphasis is made on such misconception and is done so through the use of the Numeracy starters which is departmental policy. When teaching substitution, I wanted to ensure that a task was used to engage pupils and therefore decided to assess pupils understanding through a “Teacher Fact Breaker” worksheet (Appendix E). This worked well with pupils wanting to find out the true facts about myself, but soon the standard in which I expected the worksheet to be completed started to lower. Due to pupils being so determined to find out the missing word, little or no workings were being written on the sheet. Another problem identified was that once they had guessed the first two letters or so, many members of the class began to correctly guess the rest of the word. In order to address this, I had to repeat my expectations for the classwork being completed and would not accept any correct answers without workings shown. The results from the test highlight a strong understanding of the skill of substitution, however few pupils were still making the error of simply replacing the letter with the number, ignoring the process of multiplication (French 2002).

Question 9

Question 9 is a question that no pupils correctly answered in the pre-test. Having said this, the responses given from those who did attempt the question displayed a logical thought process. As expected from the literature, pupils were familiar with calculating the perimeter of the rectangle and wanted to show this in their workings. Many would choose their own values for a and b , with

the majority choosing $a = 1$ and $b = 2$ then successfully calculating the perimeter with these values. Here, students are using the idea that letters can be any number (Ryan and Williams, 2007). Of course, pupils are applying the correct method which underpins this question, however pupils do not comprehend that the answer is just a general answer which can be applied for any chosen values of a and b . When discussing the exact same question in lesson, pupils were surprised as to how our answer required no involvement of numbers and relates back the idea of pupils having a fixed idea on what an answer should look like (Wagner, 1989). Pupils seemed to be overcomplicating this question and highlighting the misconception that their answer is somewhat unfinished if there is an operation symbol in their answer (Tirosh, Ruhama and Robinson, 1998).

I will now compare the actual test results to assess the success of my intervention, leading me to my final conclusion. In the pre-test the average class score was 2/10 and the post-test 6/10, meaning that on average there was an increase of 4 marks between both tests. The increase in marks as a whole confirms that the impact of teaching through the use of pupils' misconceptions is of a positive nature and has helped pupils to identify and rectify the mistakes they were making. Although the test results did not improve massively, it may be pointed out that the post-test had to be rescheduled to a lesson after the one week Easter break, thus testing pupils' ability to retain information. My findings support the theory that addressing misconceptions during teaching improves achievement and helps pupils with the long-term retention of mathematical concepts (Askew and Williams, 1995). All pupils obtained better scores in their post-test compared to their pre-test and the two pupils who scored 0 out of 14 in the pre-test made significant improvements. The highest individual score in the pre-test was 6 out of 14 with the same pupil obtaining the highest score in the class for the post-test with a score of 9 out of 14.

In conclusion, I believe that the more aware the teacher is of the misconceptions pupils have before teaching then the more effective the teaching will be and greater success will be achieved as a result (Tanner and Jones, 2000). Misconceptions can be thought of as growth points for learning and should be used as a means of everyday practice for effective teaching. The use of cognitive conflict (Swan, 2001) is effective in helping students comprehend why their current thought process is not entirely correct and instils relational understanding (Skemp, 1976). Teaching through the use of cognitive conflict allows pupils to be confronted with the problems they may face (Tanner and Jones, 2000) and can be resolved through the use of questioning, class discussions, investigation and visual aids. Inadequate teaching would be to shy away from addressing these misconceptions and would not impact the learning of pupils for them to just know that their answer is wrong. Ignoring to explore misconceptions in teaching is not effective in driving pupil progress, we as teachers must make the effort to help pupils construct new knowledge and connect it to their previous way of thinking (Tanner and Jones, 2000). We have the

role of an enquiring teacher and must make use of research conducted by both academics and ourselves to help us enhance teaching and learning (Nias and Groundwater-Smith, 1988).

Action research is a powerful tool for both professional and personal development as a teacher (Cohen and Manion and Morrison, 2011). Self-evaluation and reflecting on practice are important skills to have when conducting research and is a standard which must be met in order to gain Qualified Teacher Status – Strand S1.7 Commitment to professional development (Welsh Government, 2009).

In order to identify areas for future development within my research and to suggest improvements which could be made, I will now study the limitations which I have faced.

The first limitation associated with my research has been the class used for my intervention. This particular class consisted of just fourteen pupils, of similar ability. By conducting my research with just one small class in one school, I am only able to compare and contrast the data of pupils of similar ability. Ideally, not only using a larger class would have been more effective to my research but also conducting the research to a number of classes ranging in abilities. This would be more effective as I could use comparison groups to analyse the data from the pre and post measurements, this would then improve the validity of my results found.

Another limitation faced when conducting my research was the time allocated for post testing. The pre-test was taken as a starter activity before my first lesson of starting the algebra topic and before the four lessons planned for my intervention commenced. The post test was then scheduled to be conducted at the end of the four lessons which happened to fall on the last day of the school term, before the Easter holidays. At this time in the school year End of Term Easter Tests had been scheduled which consisted of an open book, closed book and Numeracy test. Due to such intense testing both myself and the class teacher agreed that it was in the pupils best interest that the post-test was to be rescheduled for the first lesson back after Easter. As touched upon above, I believe that this has an impact on individual's results in the post test. The children were now not only being tested on their mathematical ability but also on how well they were able to retain the information. On one hand the rescheduling is of a positive nature as it shows the true impact my teaching has had on the pupil's memory. On the other hand, I believe that if the post-test were to be conducted straight after the four lessons taught then pupils results would be significantly higher. From this experience I have had an insight into the importance of working in accordance to scheduled events and adjusting my planning to adhere with school policy.

I have always found it interesting when teaching to listen to pupils express their thought process when answering a question. Through class discussions and adopting the think, pair, share strategy in my lessons I am able to further question and probe pupils understanding of mathematical ideas and concepts. A methodology I would choose to use in future research to

support my data is the use of interviews to gain more qualitative data of answers given to the pre and post-test. Through the use of an interview I would be able to have a guideline of the types of questions going to be asked but would also ensure there exists an element of freedom within the interview to explore the pupils learning and thought processes (McAteer, 2013). Although a disadvantage of interviews is that they are often time consuming and difficult to organise within lesson time, I believe that making efforts to understand the way in which individual pupils learn best would have been beneficial to my planning of lessons as I only had chance to observe very few lessons before I acted as the class teacher.

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Appendix

A – The Pre and Post-test

B – The Departmental Scheme of Work

C – The Topic Pack

D – Consent Form

E – Worksheet Used for Substitution Lesson

Appendix A

Student Name:

What Do You Already Know?

This assessment is designed to help you with algebra, by helping your teacher understand the mistakes you make, as well as why you make them.

You have 15 minutes to complete 10 questions.

Please attempt **ALL** questions and use the blank space for workings.

1. $a + a + a + a =$

2. $5y - y =$

3. $4d + 2e - d + 3e =$

4. $6m + 2c =$

5. True or false

(a) $a + b = b + a$

(b) $a - b = b - a$

6. $c \times c =$

7. $4g \times 2h =$

8. If $x = 3$ then calculate $4x - 5$

9. Calculate the perimeter of this rectangle

a cm



Appendix B

Scheme of work plan for the academic Year 2017/2018

Stage 2		
Year 8 - South		
Autumn 1		
Use number facts and relationships		
Fractions, decimals, percentages and ratio		Reasoning
Calculate using mental and written methods		
Estimate and check		
	Open Book Tests	Test
Autumn 2		
Manage money		
Length, weight/mass, capacity		Reasoning
Time		
	Open Book Tests	Test
Spring 1		
Area and volume		
Angle and position		Reasoning
Movement		
Spring 2		
Expression and formulae		
Functions and graphs		Reasoning
Equations		
Summer 1		
Collect and record data		
Present and analyse data		Reasoning
Probability		
Year 8 ICT project		
Summer 2		
Shape		
Number sequences		
Construction		

Scheme of work plan for Spring 2 – Expressions and Formulae

Expressions and Formulae 2	Textbook exercises	Extra Resources	Problem Solving Questions
Show that $a + b = b + a$ and $a - b$ is not equal to $b - a$		Expressions	Expressions
Show that $a \times b = b \times a$ and a/b is not equal to b/a		Expressions	Expressions
Know that $4g \times 2h = 8gh$			
Know that b divided by 2 is notated as $b/2$ and $1/2b$			
Substitute positive whole numbers into one and two step expressions		Substitute	Substitute
Simplify expressions involving the addition and subtraction of two or more variables		Simplifying	Simplifying
		Simplifying	

Appendix C

Below is an example of the lesson plan and resources used for the first lesson taught – Simplifying Algebraic Expressions involving Multiplication.

This lesson includes a lesson plan and supporting PowerPoint which are attached below. The Lesson plan highlights the AfL strategies used along with my personal self-evaluation of the lesson.

Lesson Plan



LESSON PLAN Simplifying Algebraic Expressions (Multiplication)

NAME: Gabrielle Jones	DATE / TIME: Tues 6/3/18 WA Lesson 4	PERSONAL TARGET(S): Good pace & timings are kept
LEARNER CONTEXT: <i>(Eg. Class, number of learners, any specific requirements, notes from last lesson)</i> Class 8N7 -14 pupils <u>Additional Info:</u> Dylan requires – blue paper printing – PowerPoint hand out		
LESSON CONTEXT: <i>(Eg. Where does this lesson fit in a sequence? What subject specific skills are learners developing? Any notes from last time I taught this lesson)</i> Last lesson: - Collecting like terms Learners will be able to: - Simplify terms using addition and subtraction using one/two variables - Understand that algebra involves any letters - Be able to use keywords when discussing answers and thoughts		

OBJECTIVES:

(What do I want learners to know or be able to do at the end of the lesson)

- Be able to simplify expressions involving multiplication (including squared terms)
- Be able to simplify simple expressions involving division

From the SOW:

- Show that $a \times b = b \times a$ and a/b is not equal to b/a
- Know that $4g \times 2h = 8gh$ or $8hg$
- Know that b divided by 2 is notated as $b/2$ and $1/2b$

CHECKING FOR UNDERSTANDING:

(How will I know what each learner has learned? How will they know?)

- Learners will be constantly questioned throughout the lesson to test knowledge/understanding
- Encourage challenge throughout the lesson
- Learners are successful during task questions and are able to justify their method/answer
- By the end of the lesson they should be choosing the correct colour answer shown on screen

RESOURCES REQUIRED:

Workbook

Pen

ACTIVITY 1		TIMING – 8:55 – 15 mins	
TEACHER ACTIVITY <i>(What will I do?)</i> Welcome students into classroom Take register <u>Starter:</u> 7 Q's from different topics - practise questions for end of term test - questions from last lessons work Discuss starter answers and display answers on board – mixture of hands up and random names		LEARNER ACTIVITY <i>(What will the learners do?)</i> Enter classroom, stand behind chairs, equipment out Answer register, sit quietly when instructed Complete starter – working whispers Check, mark and correct answers	
REASONING <i>(Why have I chosen this? How does it link to the objectives?)</i> • Settle and engage class • Starter to recap a range of topics/ in line with maths dept. policy			
MAKING THE LEARNING ACCESSIBLE <i>(How will I ensure all learners can access the lesson?)</i> • If anyone is struggling hands up • Discussion of answers clearly shown on the board • Topics which the class have previously covered		ASSESSMENT <i>(How will I know if it's worked?)</i> • Correct answers are given – learners can self-mark their work • All learners are attentive during class discussion and participating • Any common misconceptions can be quickly addressed on the board	

ACTIVITY 2		TIMING – 9:10 – 15 mins	
TEACHER ACTIVITY (<i>What will I do?</i>) No talking, facing front, paying attention <u>Before we start:</u> which colour would you choose? Remember what colour you are, will need this for end of lesson <u>Exposition: Multiplying</u> Go through clear examples shown on board addressing any possible misconceptions – to be copied into books Examples 1: term x number Examples 2: term x term <i>Square numbers connecting to square terms</i> Any questions?		LEARNER ACTIVITY (<i>What will the learners do?</i>) Choose a colour box which they think has all correct answers: “Think, Pair, Share” Pay attention during exposition Input of ideas and thoughts to class discussion Copy and complete examples Note that we can write 20ab as 20ba	
REASONING (<i>Why have I chosen this? How does it link to the objectives?</i>) Before we start: Three questions and answers covering a variety of misconceptions. Aim for everyone to choose the only correct answer by end of the lesson. • Be able to simplify expressions involving multiplication (including squared terms) • Show that $a \times b = b \times a$ • Know that $4g \times 2h = 8gh$ or $8hg$			
MAKING THE LEARNING ACCESSIBLE (<i>How will I ensure all learners can access the lesson?</i>) • If anyone is struggling hands up		ASSESSMENT (<i>How will I know if it's worked?</i>) • All learners are attentive during class discussion and participating	

• Discussion of answers clearly shown on the board • Targeted questioning used	• Any common misconceptions can be quickly addressed • RAG pages used in planner • Learners are understanding the method used and progress in ability when looking at different questions
---	---

ACTIVITY 3		TIMING – 9:25 – 10 mins	
TEACHER ACTIVITY (<i>What will I do?</i>) <u>Exercise:</u> Standard, Plus and Challenge Try at least 4 standard Q's before moving on <i>Check answers as a class</i>		LEARNER ACTIVITY (<i>What will the learners do?</i>) Complete as many questions as possible Ask for help if needed Check answers and self-mark	
REASONING (<i>Why have I chosen this? How does it link to the objectives?</i>) • Be able to simplify expressions involving multiplication			
MAKING THE LEARNING ACCESSIBLE (<i>How will I ensure all learners can access the lesson?</i>) • Questions progress in difficulty to build confidence and create challenge • On task talking is welcome – “working whispers” • Extension		ASSESSMENT (<i>How will I know if it's worked?</i>) • Scan room and check work • Learners are working independently • Discussion of answers through questioning • Learners have correct answers • Minimal misconceptions are made • RAG Planner	

ACTIVITY 4		TIMING – 9:35 – 8 mins	
TEACHER ACTIVITY (<i>What will I do?</i>) <u>Examples 3: Division</u> <u>Question:</u> Are answers 2 and 3 the same?? Few practise questions (check timings)		LEARNER ACTIVITY (<i>What will the learners do?</i>) Follow examples shown on the board Participate during class discussions Copy examples into books Complete practise questions provided we have time	
REASONING (<i>Why have I chosen this? How does it link to the objectives?</i>) • Be able to simplify simple expressions involving division • Show that a/b is not equal to b/a			
MAKING THE LEARNING ACCESSIBLE (<i>How will I ensure all learners can access the lesson?</i>) • Class discussion – learners to support one another & combine ideas • Relate back to multiplication method • 3 clear examples are shown which will help during exercise		ASSESSMENT (<i>How will I know if it's worked?</i>) • Learners are asking good questions and are keen to develop own understanding • Learners have correct answers • Minimal misconceptions are made	

ACTIVITY 5		TIMING – 9:43 – 7 mins	
TEACHER ACTIVITY (<i>What will I do?</i>) <u>Plenary:</u> Go back to “before we start” slide, which colour box would you choose for the correct answers now? Who’s changed colour? Discuss each answer – why are they incorrect? Highlight misconceptions		LEARNER ACTIVITY (<i>What will the learners do?</i>) Now choose colour again Have they changed colour from the start of the lesson? Think, Pair, Share Discuss as a whole class answers on board, why are the wrong? What mistake have they made?	
REASONING (<i>Why have I chosen this? How does it link to the objectives?</i>) • Pupils are able to apply today’s lesson to plenary task which was introduced at the start of the lesson			

Pupils can understand why misconceptions are made and how some answers given are incorrect	
MAKING THE LEARNING ACCESSIBLE <i>(How will I ensure all learners can access the lesson?)</i> Visual on board	ASSESSMENT <i>(How will I know if it's worked?)</i> - Pupils can understand why misconceptions are made and how some answers given are incorrect - Pupils now choose the correct colour box

PRE-LESSON CHECKLIST

Will learners be developing their skills in...

- ☐ Literacy?
- ☐ Numeracy?
- ☐ Digital Competence?
- ☐ Does this lesson contribute to a specific element of one of the frameworks? Y / N How?
- ☐ Y Cwricwlwm Cymreig?
- ☐ ESDGC?

Have I considered... (Adapted from Fletcher-Wood (2016))

- * Hook: How does the opening task get the learners interested and thinking?
- * Model: Is it clear to the learners what success looks like?
- * Focus: What will this lesson make the learners think about?
- * Access: Can every learner access the main ideas of the lesson?
- * Challenge: How will every learner be challenged by this lesson?

EVALUATION

(How did the lesson go? What points will I take forward to the next lesson? Could I use this lesson as evidence in my PDP?)

A lot of mathematical content in today's lesson and concepts which learners needed to understand. Coped well and I think "chunking" the lesson was necessary.

Plenary – all learners could understand why it was the yellow box which was correct. AfL technique was really effective!
 (See comments box in powerpoint for misconception considerations)

With regards to Exercise – Standard, Plus, Challenge: This is a class who really do want to succeed during lessons but must emphasise that you must complete standard questions before moving ahead with plus. Great to see pupils eager and keen to challenge themselves but standard questions underpin the key concept we must make sure we understand.

Supporting PowerPoint Slides

Show that $a \times b = b \times a$ and a/b is not equal to b/a

Know that $4g \times 2h = 8gh$

Know that b divided by 2 is notated as $b/2$ and $1/2b$

Comments

New

Gabrielle Jones (1700806) 4 minutes ago
SOW requirements - for my own knowledge

Reply...

Title: Simplifying Expressions **8N7**

Objectives: • To be able to collect like terms
(Don't write) • To be able to simplify expressions involving multiplication and division

Starter

1) $94 - 36 =$

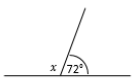
2) $14 + \bigcirc = 58$

3) $4 - \bigcirc = -5$

4) $73 - 27 =$

5) $170\text{cm} + 52\text{cm} =$ m

6) Find the missing angle 'x'



7) Simplify

a) $4p + 2p - p$

b) $8x - 5y - 3x + y$

c) $8a + 7 + 2a + 2$

d) $7m + 3n$

Extension
 $*10n - (n + 5n)$

Comments

New

Gabrielle Jones (1700806) 4 minutes ago
Numeracy starter - departmental policy

Reply...

Which colour box would you choose for both correct answers? 🤔

1) $6h \times 2g = 62gh$	1) $6h \times 2g = 12gh$	1) $6h \times 2g = 12hg$
2) $a \times a = 2a$	2) $a \times a = 2a$	2) $a \times a = a^2$

Think, Pair, Share

Comments

New

Gabrielle Jones (1700806) 4 minutes ago
Think, Pair, Share could be used here or individual thinking time with think, pair, share at the end of the lesson

Gabrielle Jones (1700806) 1 minute ago
IMPORTANT - enough thinking time is given

Reply...

Examples 1

1) $a \times 2$

2) $3b \times 5$

3) $9 \times 4h$

Comments

New

There are comments on other slides in this presentation.

Use the Next and Previous buttons to see them.

Examples 2

1) $4a \times 5b$

2) $3h \times 4g$

3) $m \times 4s$

Comments

New

Gabrielle Jones (1700806) March 06, 2018

Mention 20ab = 20ba

Reply...

2×2

4×4

5×5

10×10

What do we call a number that's multiplied by itself?

$c \times c =$

$a \times a =$

Comments

New

Gabrielle Jones (1700806) March 06, 2018

identify square numbers before introducing letters

Reply...

Gabrielle Jones (1700806) March 06, 2018

it is NOT $2c$ and $2a$ - must address this common misconception

Reply...

Exercise Always try (at least) any 4 **standard** before moving on

Standard

1) $6b \times 7$

2) $5m \times 6$

3) $3h \times 7$

4) $6f \times 11$

5) $a \times 7$

Plus

1) $9f \times 4p$

2) $3b \times 7t$

3) $5p \times 6b$

4) $3h \times 3t$

5) $f \times 10s$

Challenge

1) $p \times p$

2) $a \times a \times a$

3) $h \times 2h$

4) $4a \times 2a$

Comments

New

Gabrielle Jones (1700806) 5 minutes ago

Differentiated Task

Reply...



Which colour box would you choose for both correct answers?



1) $6h \times 2g = 62gh$

2) $a \times a = 2a$

1) $6h \times 2g = 12hg$

2) $a \times a = 2a$

1) $6h \times 2g = 12gh$

2) $a \times a = a^2$

Think, Pair, Share

Have you changed colours from before?

Comments

New

Gabrielle Jones (1700806) March 06, 2018

PLENARY - talk about misconceptions which should be a pupil led discussion

Gabrielle Jones (1700... March 06, 2018

have they changed colour box? if so then this shows that they have ironed out their own misconceptions

Gabrielle Jones (1700... March 06, 2018

why have they chosen this box now?

Reply...

Gabrielle Jones (1700806) March 06, 2018

will they pick blue because of order of h and g??

Reply...

Appendix D



PRIFYSGOL CYMRU
Y Drindod Dewi Sant
UNIVERSITY OF WALES
Trinity Saint David

Is-Ganghellor/Vice-Chancellor Medwin Hughes DL DPhil DPS FRSA

Participant Identification Number:

SAMPLE CONSENT FORM

PROJECT TITLE:

Name of Researcher:

Investigating pupils' misconceptions in (topic) by a pre written test on (topic) , teaching (topic) and a post written test on (topic).

Please initial box

1. I confirm that I have read and understand the information sheet dated **XXXX** for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason. ☐

3. I understand that any information given by me may be used in future reports, articles or presentations by the research team. ☐

4. I understand that my name will not appear in any reports, articles or presentations. ☐

5. I agree to take part in the above study. ☐

Name of Participant

Date

Signature

You may decline to participate in this study. You may end your participation in this study at any time. If you decide to remain anonymous, maintaining your anonymity will be a priority and every practical precaution will be taken to disguise your identity. If you prefer anonymity, there will not be any identifying information on audiotapes or transcripts of this or any interview. No-one will hear any audiotapes or see any transcripts without your prior consent. All materials generated from this or any interview will remain confidential.



Participant Identification Number:

SAMPLE PARTICIPANT INFORMATION SHEET

PROJECT TITLE:

***THIS FORM IS TO BE AMENDED AND ADAPTED AS NECESSARY**

Dear Participant:

My name is XXXX and I am studying in the School/Faculty of XXXX.

I would like to invite you to participate in my research project. This project will research misconceptions in (topic) and aims to investigate pupils' use of misconceptions in (topic) by pre and post diagnostic tests.

Through your participation in the tests, I hope to ascertain the use of misconceptions in (topic)
All tests will be kept strictly confidential to the researchers involved and at NO time will individual tests be released to the general public. Your participation in this study is completely voluntary so you can withdraw your permission for your test data to be used for my research at any stage.

We thank you in advance for your time and participation. If any questions do arise, feel free to contact me at your convenience.

Yours Sincerely

Appendix E

Substitution

What can you find out about your teacher?

Use your knowledge of algebra to work out the facts about Miss Jones!

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26

In all of the facts, $a = 7$, $b = 9$, $c = 4$, $d = 10$

1. When I was _____ years old I broke my _____.

$$c + d$$

$$a - 6$$

$$a + 2$$

$$2b$$

$$2a$$

$$2a - 1$$

$$a - 2$$

2. My _____ subject in school was _____.

$$c^2 - 10$$

$$c^2 - d$$

$$c - 3$$

$$d + 8$$

$$2d + 2$$

$$c + 1$$

$$d + 5$$

$$2b - c$$

$$3d - 9$$

$$d - 7$$

$$c + 14$$

$$2c$$

$$4c - a$$

$$2d$$

$$b - c$$

3. My _____ is on the same day as the _____.

$$b - a$$

$$d + c + 3$$

$$a + 2$$

$$2d + 1$$

$$b + 9$$

$$d - a + 2$$

$$d + 10$$

$$b - 4$$

$$2c$$

$$2d - 6$$

$$d - 6$$

$$d - b$$

$$3d - 5$$