To explore ESOL/EAL specific teaching and learning interventions of key words and phrases in the GCSE maths classroom and how they impact on learners' progress

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About CfEM

Centres for Excellence in Maths (CfEM) is a five-year national improvement programme aimed at delivering sustained improvements in maths outcomes for 16–19-year-olds, up to Level 2, in post-16 settings.

Funded by the Department for Education and delivered by the Education and Training Foundation, the programme is exploring what works for teachers and students, embedding related CPD and good practice, and building networks of maths professionals in colleges.

Summary

Language plays an important role in Mathematical teaching and learning, Mathematics learning does not only require computational ability and concept understanding but there is a vital role that language plays. “Mathematics learning is a triad: language learning, procedural competence and conceptual understanding” (Stacey, 2018). The main aim of this study is to explore ESOL specific teaching and learning interventions of key words and phrases in the GCSE maths classroom. To this end, we have chosen ten commonly-used yet ambiguous words i.e. words that have a different meaning in everyday English to their meaning in maths. We designed an intervention in which we pre-teach learners the English and maths definitions of words and learners complete the heavily adapted Frayer model at the end of each intervention session. To check the effectiveness of the intervention we administered pre-diagnostic and post diagnostic tests with questions that use the ambiguous terminology for the learners to complete and we also collected learners’ opinions and teacher reflections at the end. There were 5 teachers and over 100 students that completed the pre-diagnostic and post-diagnostic tests. We also gave learners an initial language questionnaire that allowed us to classify learners as ESOL and non ESOL.

When we fit a regression model to the data, we found out that ESOL learners did better than the non ESOL learners in both the pre diagnostic and post diagnostic tests. We also found out that both cohorts have increased their maths scores from pre diagnostic to post diagnostic tests.

When we considered the learners who completed both diagnostic tests, we observed a statistically significant difference in the means of pre diagnostic and post diagnostic tests, specifically, the post-test mean was greater than pre-test.

We also found out that on average, the percentage of learners who know or have an idea of the English definition/meaning and maths definition/meaning for each word and the proportion of the correct definitions/meaning increased after the intervention. Therefore, when teaching the vocabulary, we included the non ESOL, because they benefited from the interventions in the language of mathematics.

Contents

1. Introduction

Newham College is a large Further Education (F.E.) College situated in the London borough of Newham, in the heart of the Inner East of London. Newham has one of the youngest populations in the country, as well as having a high proportion of Black, Asian and minority ethnic (BAME) residents.

Newham College has two main sites – one in East Ham and the other in Stratford – and offers a wide range of courses from Entry to Level 4/5 for 16-19-year olds and adults. There were 540 learners doing GCSE maths this year and 91% of these were BAME. The achievement rate for GCSE in 2018/2019 was 96% (including 27% Higher Grade), for 2019/2020 the achievement rate was 98% (including 35% Higher Grade)

The maths team at Newham College deliver maths across the full range of vocational subjects as part of the 16-19 Study Programmes and to adults studying at the College.

70% of 16-18 students who enrol at Newham College have not yet achieved a GCSE grade 4 or above in English and/or maths and therefore need to either resit these exams or take Functional Skills in order to develop the skills needed to achieve a GCSE 9-4 qualification before they leave College.

The College is committed to providing a high-quality learning experience that meets the needs of its students ensuring they can progress into employment and/or further/higher study.

Newham College is a Centre for Excellence in Mathematics (CfEM). CfEM is a beacon that draws together other organisations/institutions who share common aims and values in the sector and allows a platform to draw on best practice and ideas. It is also a platform that is resourced and dedicated to allowing and enabling research that provides tangible outcomes and evidence that can inform sector wide practice.

1.1 Why this topic?

In 2019/2020 Newham College and its CfEM partners researched the question ''How do learners with English as a second language respond to teaching interventions of key words and phrases specific to GCSE maths.''
In 2020/21, we wanted to build on this action research and wanted to refine both the use of the Frayer Model for use in the classroom and in collaborative planning, to identify specific key terminology and expose misconceptions, and to develop and trial new teaching interventions for GCSE maths learners with ESOL needs. The terms ESOL and EAL are used in this report, meaning English as a Second Language and English as an Additional Language, respectively.

Our research topic was influenced by the large number of ESOL learners within our organisation and within our network of colleges, and the low levels of formal qualifications in English that our learners have on joining the College. Well over 60% of maths learners who were surveyed stated that English was not their first language within Newham College. Most learners joined the College without any formal qualifications in English or maths (74%) compared to 32% nationally for General FE colleges. Approximately three quarters of learners who study at the College main sites and community venues are from a black or minority ethnic heritage background. A range of social indices confirms that many of the borough's residents are faced with extreme socio-economic challenges, English language being a part of this.

The College and its Network partners offer a wide range of ESOL courses to support the learners and we work alongside ESOL colleagues to inform practice and ideas.

This topic has been picked up by the ETF/University of Nottingham, two organisations running CfEMs on behalf of the DfE, as an additional strand for 2020/2021 and it also fits well within the framework of mastery. If learners cannot access the language, they cannot master the maths and are less likely to make progress and achieve. This is supported by current national policy to improve both maths and English language skills within the post 16 sector and the College's own vision ***"To give our students the confidence, skills and qualifications that employers need, and that will support local people to get great jobs."***

Majewska (2019) states that; '"EAL learners may find the shift from conversational to mathematical language more difficult than native speakers and may require more time to develop mathematical language proficiency than their peers.'' This supports our research, as we aim to spend time exploring ways that we can allow learners in the maths classroom time to develop their language skills in order that they can successfully access the syllabus, resources and the exam.

The main aim of this study is as follows: "to explore ESOL/EAL specific teaching and learning interventions of key words and phrases in the GCSE maths classroom with a particular focus on how best to support learners who have previously struggled with maths and who have reached the age of 16 without a maths GCSE grade 4 or above through the teaching of 'Key Words and Phrases' in the GCSE maths classroom and how they impact on learners' progress.

Hence the title of our project is: "To explore ESOL specific teaching interventions of key words and phrases in the GCSE maths classroom and how they impact on learners' progress".

2. Literature Review

Introduction

Within the CfEM Newham network, there are a significant number of learners that have English as a second language and, over the years, as practitioners, there is an observation that language hinders and forms a barrier to the learning of mathematics for the ESOL/EAL (/English to Speakers of Other Languages/ English as an Additional Language learners). We see learners with mathematical ability that struggle to participate in classroom activities and underperform in their GCSE maths and functional skills maths exams, because of the limited language skills. Many pupils with overseas educational backgrounds who are learning to use English as an additional language may find classroom spoken language more difficult to access than written text in a subject such as mathematics (Barwell, Leung, Morgan and Street, 2002).

Due to COVID, teachers are now required to provide blended delivery and blended learning opportunities and carry out research remotely using technology. Arthur & David (2020) comment on teachers needing to change their practice so rapidly – they are faced with "a very steep learning curve when it comes to using digital tools and finding creative solutions to practical problems" (Arthur & David 2020)

In this action research (AR), we will investigate the language barriers that ESOL/ EAL learners encounter when undertaking GCSE maths resits and will carry out pedagogical interventions to measure effectiveness in helping learners overcome those barriers and improve their understanding of mathematics and enhance their attainment. Chad (2007) lists the issue facing mathematics learners as:

1. There isn't a consistent uniform version of maths vocabulary.
2. Students are unable to recognize and recall maths terms.
3. Some terms' definitions differ in maths context than in everyday usage.

This literature review is divided into five sections. The first section gives a brief overview of the importance of language in mathematics learning. The following three sections present themes found to be common in the literature review i.e. vocabulary, mathematics register and word problems. The last section gives our conclusion of the literature review

2.1 Importance of Language in Mathematics Learning

A growing body of literature has examined the impact of the language on mathematical learning. Mathematics learning does not only require computational ability and concept understanding but there is a vital bridging role that language plays. “Mathematics learning is a triad: language learning, procedural competence and conceptual understanding” (Stacey, 2018). This was informed by the importance of thought and discussion as an aid to learning mathematics, which has led to the view that restricted thought or talk can lead to restricted learning (Sfard, 2008; Barwell, 2009; Woolley, 2013, cited in Stacey 2018).
Stacey (2018) points out that language structure and language content have a substantial impact on students’ ability to engage with mathematical material and thus presents serious challenges to students for whom English is their second language. There is growing recognition that language (and bilingualism/multilingualism) plays a key role in mathematics teaching and learning. Given the increase in international migration, the changing status of minority/indigenous groups and the dominance of English as a language for learning and teaching mathematics, many students face a transition to learning mathematics through the medium of another language (Barwell, Barton & Setati, 2007- pg. 9, cited Coben et al, 2015).

This AR group subscribes to the idea that language forms the wheels that drive mathematical learning and without proper understanding of the mathematical language, learners will not achieve fluency and the deeper understanding needed to progress. Maths is a language that has got its subject-specific vocabulary; therefore, “to be fluent in that language, one should be able to use and understand vocabulary” (Chad, 2017).

In their recent paper about the contribution of language ability to mathematics learning, Natthapoj et al (2020) argue that there are four key experiences in mathematics learning, language being one of them. These are concrete manipulation, pictures and symbols in addition to language (Bruner (1966), Haylock and Cockburn (2013), cited in Natthapoj et al, 2020)

Petersson and Norén (2017) undertook a study in Sweden in which they investigated the test responses of immigrants and non-immigrant learners in Swedish schools. They observed how the learners solved two problems based on fractions, one of these problems being halving a fraction. They found out the newly arrived second language immigrants in Sweden appeared less likely to have the word half in their Swedish mathematical vocabulary. The early arrived immigrant learners who lived longer in Sweden managed to connect the word half to division by 2 but find it hard to correctly apply it to fractions.
In our teaching experience we have found that in order for learners to learn mathematics, they need to understand the language of mathematics. However, we have also found that the language of mathematics can create some confusion for not only EAL/ESOL learners but also to EFL(English as a First Language) learners.

Whilst accepting of the fact that there is a multiplicity of inter-connected factors, we provide 3 key reasons why EAL/ESOL learners find it hard to understand the language of mathematics:
1. There are words that have some meaning in everyday English and another meaning in mathematics.
2. We observed that some learners struggle to differentiate and understand the difference between pairs of words that represent topics that are closely related and interlinked. Examples of these are: Multiples and Factors, Estimate and calculate
3. Some learners struggle to make sense out of word problems.

2.2 Mathematics Register

There are different uses of some words in different contexts and this might create cognitive overload to the second language learners who are learning English and mathematics at the same time. Halliday (1978, p. 195, cited in Jourdain & Sharma 2016) defines maths register as a "set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings".

There are mathematics and English language registers, some vocabulary may change meaning between registers, i.e. there are words that have a meaning in everyday language and a different meaning in the mathematical register. EAL learners find it hard to work between the mathematical register and the English register (Jourdain & Sharma, 2016). The process of learning mathematics inevitably involves the mastery of the mathematics register (Setati, 2005, cited in Coben et al 2015) "without this fluency, students are restricted in the ways that they can develop or redefine their mathematical understandings" (Meaney, 2005, p. 129, cited in Coben et al, 2015). Developing a learner's mathematical register provides them with analytical, descriptive and problem-solving skills within a language and a structure through which they can explain a wide range of experiences (Ní Ríordáin, Coben, & Miller-Reilly, 2015: page 13).

2.3 Vocabulary

In their recent literature review (Coben et al, 2015) identified the number of "borrowed words" from everyday English as a key issue that causes significant problems for second language learners (as well as monolingual learners) (Pimm, 1987, cited in Coben et al 2015). These words tend to be ambiguous due to having one meaning in the mathematics register, while having another meaning in everyday use, examples of such words include average, degree, even, odd, operation, (Yushau & Bokhari, 2005, Cited in Coben et all 2015). The non-mathematical meanings of these terms can influence mathematical understanding, as well as being a source of confusion.

Kotsopoulos (2007) states that for these learners, when coming across these "borrowed words" mathematics can seem like a foreign language. (Jourdain & Sharma, 2016) note that "It is important that students are taught these words in a mathematical context because they will differ from their everyday English use".

Cummins' (2003, cited in Natthapjot et. Al 2020) made distinctions between the Basic Interpersonal Communicative Skills (BICS) and Cognitive Academic Language Proficiency (CALP). Acquiring CALP is particularly challenging for learners whom the language of instruction is not the first language (Natthapjot et. Al,2020).

According to Stacey (2018), the absence of a body that oversee the quality of English language content has led to the proliferation of single words that have more than one meaning, only one of which is mathematical. Examples of these words include product, factor, modal, chord, table, change and expand (Stacey, 2018).

2.4 Word Problems

Being able to solve mathematic word problems is a fundamental skill that promotes creative thinking and enables the students to think in a logical manner. It enhances their understanding of how mathematics can be applied to real life situations and can improve their analytical skills and comprehension.

English speaking students are likely to be drawing on a considerable knowledge of the construction, content and meaning of the phrases and questions they are given, whereas those without English as a first language may be focused initially on the translation, before reaching a point where they can process the mathematical content.

At the very least these students may need more time to cover the same amount of work (Swan & Smith, 2001 cited in Stacey 2018).

Abedi and Lord (2002) undertook a systematic study of the impact that language has in mathematics learning. They found that there was a large gap in mathematics results between English language learners and students from English speaking backgrounds when assessed using word problems.

More recent evidence by Natthapoj et al (2020) shows that EFL learners significantly exceeded EAL learners in the word-based component of the mathematics test only. Their analysis also revealed that there are differences in how reading comprehension ability is related to the mathematical word problem solving performance for EFL and EAL learners.

Jourdain and Sharma (2016) discuss the importance of using word problems in mathematics classrooms, they state that students can gain a deeper understanding of specific concepts when applied to a real-world context. They continue and write that word problems should be written in a way to allow students to understand the meaning of a problem, as opposed to using it as a means to demonstrate mastery and understanding of a computational property (Barwell, 2005; Moscardini, 2010 cited in Jourdain and Sharma, 2016).

2.5 Conclusions

The need to understand mathematics and its terminology is greater than ever during the pandemic. In fact, this point is summed up by Arthur and David (2020) by saying “The pandemic requires the whole population to be much more mathematically literate” when exposed to statistics in the media as an example.

Language is vital in mathematics learning as Sierpinska (1994, cited in Coben et al 2015) stated that when working with bilingual/multilingual learners. We need to be acutely aware of their languages and how these languages may impact on their mathematical thinking and learning as language is necessary to facilitate mental representation and manipulation of written mathematical text.

Jourdain and Sharma (2016) remind us that “teachers need to be aware of issues surrounding teaching mathematics to English language learners and plan accordingly”. They continue and say that being unaware of these issues can have a negative impact for the learning of all students.

After reviewing literature, we decided to focus on a 5 week long intervention. We wanted to see if teaching two ambiguous words each week will help learners to learn and familiarise themselves with some ambiguous words that appear in both the English and maths register.

The aim was to use an intervention technique which can easily be embedded into a lesson. There was a focus to not create another layer of difficulty for the learners. Ashcraft (2002, cited in Stacey 2016) reiterates that teachers need to understand the cognitive load on students, and that asking students to complete multiple tasks in the classroom can slow learning. Our Action Research is linked to maths mastery as it encourages the use of 'lexicon for deep mathematical learning'. Curtis (2018) points out that the mathematics mastery approach empowers mathematics teachers to allow all pupils to experience a deep mathematical understanding and give the teachers a common language to explicitly use when evaluating pupils' quality of mathematical learning.

3. Methods

We collected a mixture of qualitative and quantitative data including English and maths definitions of ten ambiguous words, scores of the maths questions based on those words and teacher reflections and learner feedback.

The language questionnaire *(Appendix C)* is used to categorise learners into ESOL and non ESOL learners. The pre-intervention diagnostic assessment *(Appendix D)* was conducted to establish the learners starting point before the Intervention lessons are delivered. The key areas of delivery include an innovative approach to teaching everyday English meaning and Mathematical meaning of ten ambiguous words and the use of *a heavily adapted Frayer model (Appendix A).*

In addition, post-intervention diagnostic assessment *(Appendix E)* was conducted with the aim of evaluating the Intervention lessons. A learner's questionnaire *(Appendix F*) was administered to determine the students' comments and feedback from the intervention and lastly teachers' reflection questionnaire *(Appendix G*) was administered to ascertain the teachers' feedback from the overall intervention.

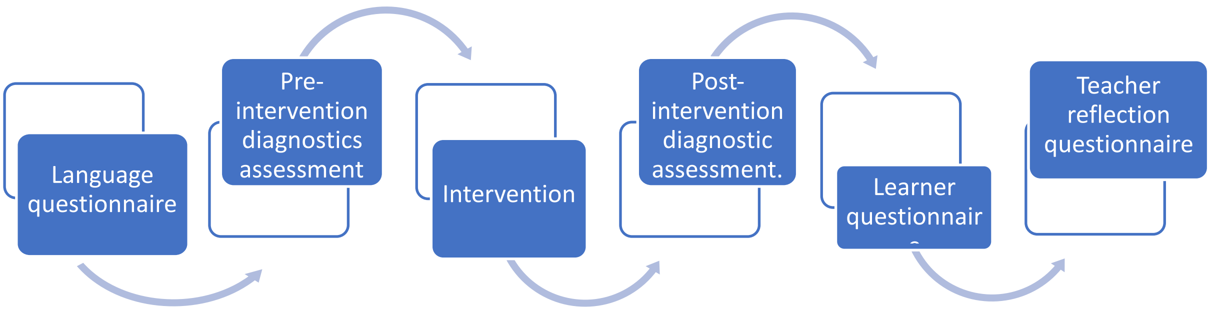


Table 4.1 below gives a summary of the number of respondents for each the data collection method.

Data collection tool	Number of respondents	Data collection method.
Language questionnaire	141	Ms forms Online
Pre-diagnostic test	114	Ms forms Online
Post-diagnostic test	133	In class
Post- intervention questionnaire for the learners	95	Ms forms Online
Teacher reflection collected using	5	Ms forms Online

Table 4.1

While at the planning stage we planned the intervention lessons to be delivered in class and put the words and their definitions on the wall. But the classroom-based intervention did not happen due to the lockdown, so we had to adapt and use the Padlet *(Appendix B)* instead as a word wall. Due to COVID, learners also completed the "*heavily adapted Frayer model"* online using Whiteboard.fi. And in April we had to revert back into class teaching and learners completed the heavily adapted Frayer model on paper. so, three intervention lessons were delivered online and two in class.

Learners were notified about the Action Research and that their responses will be anonymised.

The target group for this Action research was 254 learners re-sitting the GCSE maths exam. Learners were in the 16-18 age group and a large number of them identified as being a second language English speaker. Learners were based in two campuses, East Ham campus and Stratford campus.

The intervention lessons were based on two ambiguous words in each lesson. The lesson started with pre-teaching of the English and maths meanings of the two words using a collaboratively planned PowerPoint *(Appendix H).* The learners discussed their definitions of the words and they were put on the Padlet together with the pictoral representations and examples of the words. These Padlets remained live throughout and after the lesson so that the learners could access it when they needed. The maths topics based on the two ambiguous words were then taught to the learners throughout the lesson. At the end of the intervention lesson, the students needed to complete a heavily adapted Frayer model style template for each of the two words using whiteboard.fi. in order to assess learning.Whiteboard.fi was used during online classes and a paper template was used in classrooms.

What do we want to change and what will we measure?

1. To explore literature to support the rationale and findings for the research
2. To describe and understand the language barriers faced by ESOL learners in the GCSE maths class
3. To collaborate with ESOL colleagues in the design of the teaching interventions/resources and best practice
4. To investigate how learners respond to the teaching intervention and strategies.
5. To compare and contrast findings between two groups of learners; ESOL learners and non ESOL learners.
6. To collect and use teacher reflections on ease/usefulness of each intervention.
7. To share best practice and findings internally and externally.

4. Results and Discussion

In this section we present the results and the analysis of the data. This section is divided into 4 sub sections. In the first subsection we will present the results of the language questionnaire. The second subsection is the longest and we will present the analysis of the data from the diagnostic tests i.e. the scores, analysis of English and maths definitions and analysis of the follow up question. Then, in the third and the fourth subsections, we will present the results from the post-intervention learner questionnaire and the teacher reflections. And in the final section we will finally present the overall discussion.

4.1 Language questionnaire

The five teachers participating in the study administered a language questionnaire *(Appendix C)* to the students. The learners were asked to respond to 8 questions administered through online MS Form. They were required to state when they started studying in UK, whether they consider English to be their first language and how long they have been speaking it. In addition, they were asked how many languages they can speak and if language was a barrier to learning Mathematics. Lastly, they were asked if they were or were not studying GCSE and Functional Skills English, and if not, they were asked to explain why.

The data shows that 28% of the 141 respondents either agreed or strongly agreed that language is a barrier to their maths learning while 18% were neutral to the statement.

The responses show that 63% of the respondents are studying English (either GCSE or functional skills) while 37% are not studying English now. Some of the data of the language questionnaire is coded and with the help of the ESOL specialist, we categorised 37% learners as ESOL, while 63% classified as non ESOL.

4.2 Pre-diagnostic and post-diagnostic data

Pre-intervention diagnostic assessment *(Appendix D)* was used as a baseline to ascertain the learners starting point. Pre-diagnostic assessment allows teachers to determine learners' individual strengths and weaknesses and therefore acts as an initial point for intervention.

The assessment established students' pre-intervention knowledge and understanding of the everyday English meaning of the words, the mathematical meaning of the words and calculations related to the words. In addition, learners were asked to state whether they understood the question and answered it, or they do not know the question and cannot do the calculation, or they don't understand the meaning of the words at all.

The ten ambiguous words that the intervention and the assessments is based on, are words with different meanings in everyday English and Mathematics. The ten chosen words are: Expression Expand, Estimation, Roots, Base, Reflection, proportion, Translate, Compound and Similar.

After a 5-week intervention, a thorough post-intervention diagnostic *(Appendix E)* which was similar to the pre-diagnostic test was put together and administered to the learners in class. All the questions were marked by the respective teachers and the marks entered into a spreadsheet which was later analysed.

4.2.1. Comparing pre-diagnostic scores with the post-diagnostic scores

There were 114 learners who completed the pre-diagnostic assessment and 133 completed the post-diagnostic assessment. The mean score of the maths diagnostic questions of the pre-test is calculated to be 6.22 while the mean score of the post-diagnostic were 6.67 rounded to two decimal places which shows an increase of 0.45.

There were 74 leaners who completed both the pre-test and the post-test, and we compared the marks of these learners. The data of the pre-test and the post-test was run on a paired t-test using Excel.

t-Test: Paired Two Sample for Means		
	Pre- test	*Post-test*
Mean	6.77027027	7.689189189
Variance	8.179378008	14.18974454
Observations	74	74
Pearson Correlation	0.664654095	
Hypothesized Mean Difference	0	
df	73	
t Stat	-2.786413417	
P(T<=t) one-tail	0.003393671	
t Critical one-tail	1.665996224	
P(T<=t) two-tail	0.006787342	
t Critical two-tail	1.992997126	

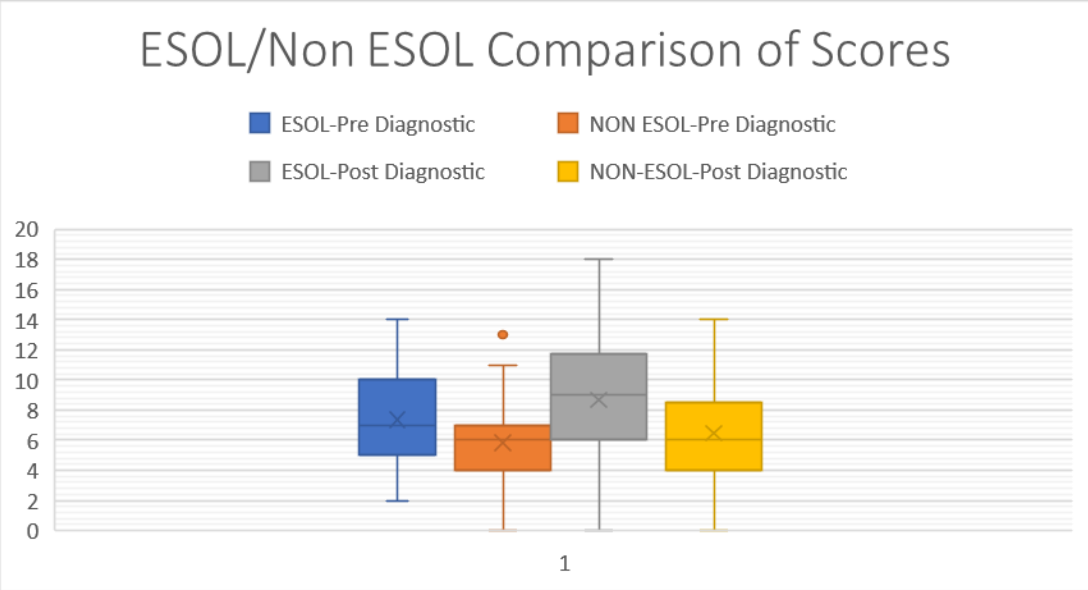
The output indicates that mean of the pre-test is 6.77027027 and the mean of the post-test is 7.689189189. The p-value is 0.006787342 which is less than our significance level (5%), and this shows that the difference of the means is statistically significant.

Our sample data supports the hypothesis that the two means are different, specifically, the post-test mean is greater than pre-test. These students were likely to have higher attendance and engagement with the course. Whilst this could be an indicator of bias, this could show that those with better engagement reaped a higher positive impact.

4.2.2. Comparing ESOL with non ESOL scores

We compared the marks obtained by the ESOL learners with those obtained by non ESOL learners in both the pre-diagnostic and post-diagnostic. We wanted to know if being ESOL or not can be a predictor of the scores i.e. if there is a difference between the scores obtained by the ESOL and non ESOL learners.

The data was represented in the flowing Box plots



The box plots show that scores of the ESOL learners have on average, improved from the pre-diagnostic test to post-diagnostic test. While the box plots for the non- ESOL learners show similar median in the pre-test and post-test, but the post-test has higher upper quartile and higher highest values suggesting a slight increase in the marks and this is supported by the mean which increased from 5.8 in the pre-test to 6.4 in the post test. This shows both cohorts improved performance, and it also shows that ESOL learners benefitted more from the intervention compared to the non-ESOL.

Pre Diagnostic test		Post Diagnostic test	
ESOL	Non ESOL	ESOL	Non ESOL
7.365854	5.843137	8.666667	6.44897959

Table 4.2.2.1

The mean scores in table 4.2.2.1 show that the ESOL learners scored better than non-ESOL in both the pre-diagnostic and the post-diagnostic tests. This difference observed in the mean is investigated further and a linear regression model is fitted to the pre-diagnostic and post-diagnostic data. The response variable is taken to be the scores and the predictor is taken to be the variable ESOL with two levels (non-ESOL, ESOL) and the base is taken to be non-ESOL.

Pre-diagnostic regression output

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	5.7	0.386724	14.73919	1E-25	4.931705	6.46829499	4.931705	6.468294991
ESOL/N0N ESOL	1.8	0.572362	3.144865	0.002252	0.6629036	2.93709636	0.662904	2.937096362

Post -diagnostic regression output

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	6.44898	0.519623	12.41088	1.32E-20	5.415471	7.482489	5.415471	7.4824887
ESOL/NON ESOL	2.217687	0.798448	2.777498	0.006771	0.629607	3.805768	0.629607	3.8057676

The regression output shows that on average, ESOL learners obtained a score that is around 2 marks higher than the non-ESOL learners in the pre diagnostic and in the post-diagnostic.

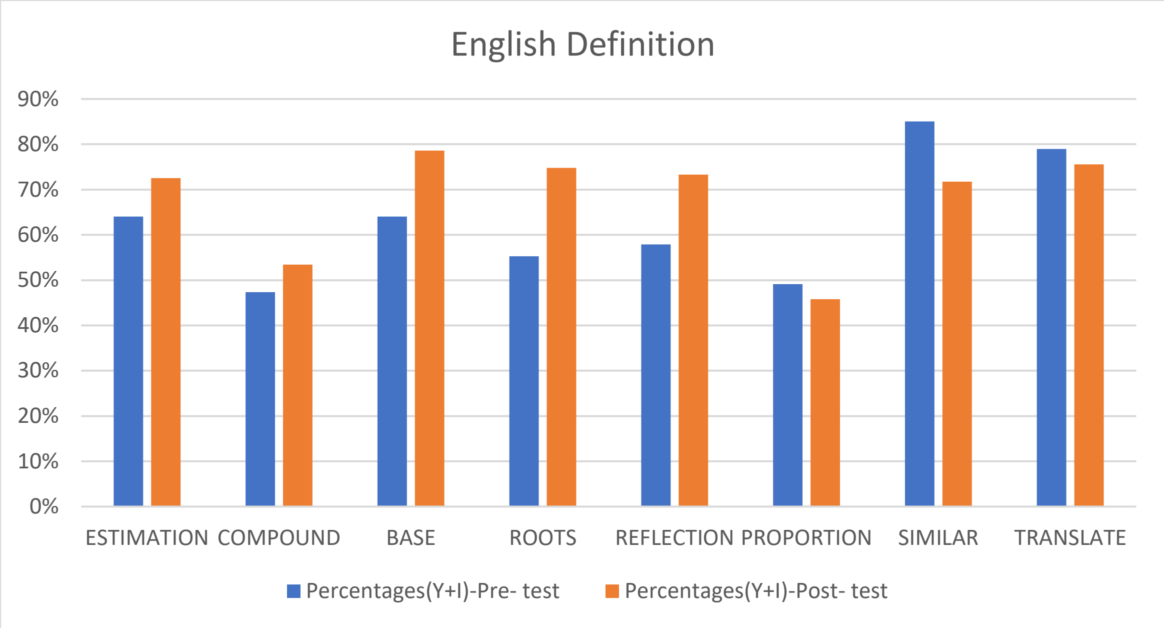
For this group of learners and for these questions the ESOL learners performed better than the non-ESOL, and there may be other factors that may be affecting the learner's marks in the diagnostic tests i.e ESOL learners may have strong mathematical skills and possibly because the questions did not include word problems which could have disadvantaged ESOL learners.

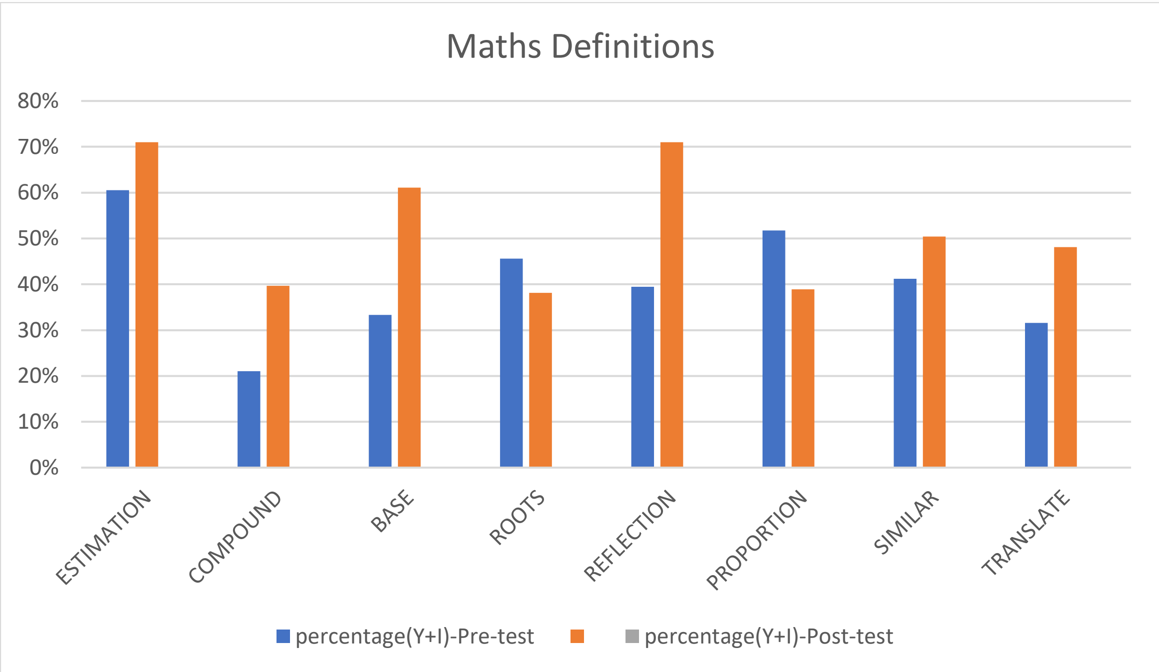
4.2.3 The Analysis of English and maths definitions

Learners were required to give the definition of the ten ambiguous words in the pre-diagnostic and the post-diagnostic test. The definitions were coded using the following notation. The pre-diagnostic was done online, therefore we added a G code for Google, but in the post-diagnostic the Google code(G) was not used because it was done in the class.

Student Response	Code
Definition is given in their own words	Y
Definition from google given	G
Definition not given correctly but learner has some idea	I
Wrong definition given	W
Definition not given	N

The data is represented by comparative bar charts.





The comparative bar charts show a clear increase in the proportion of leaners who know the English definition for the words Estimation, Compound, Base, Root and Reflection from pre-diagnostic to post-diagnostic.

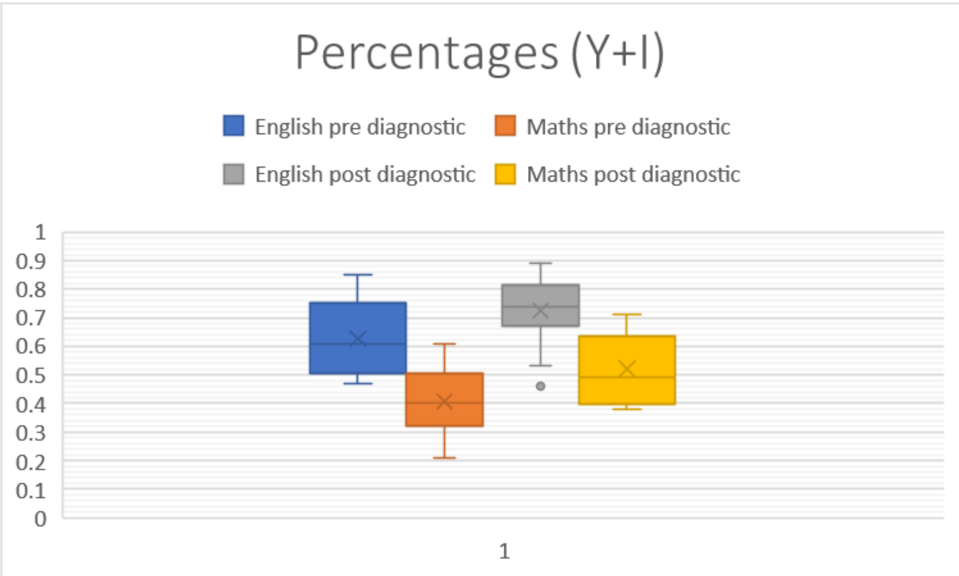
There was an increase in the proportion of learners who know maths definitions of Estimation, Compound, Base, Reflection, Similar and Translate. There was a decrease for the proportion of learners who know the English and maths definitions of the word ”Proportion”.

	Pre-test	Post-test
English	63%	72%
Maths	41%	52%

Table 4.2.3.1

Table 4.2.3.1. shows that the proportion of the correct definitions have increased for English and maths from pre-test to post-test. This shows that the intervention had an impact in learning both the English and maths definitions. Particularly the words like Compound have seen an increase because there was small number of learners who knew the maths definition.

The percentage of learners who either know Yes(Y) or have an Idea(I) for English and maths definitions for each word is represented on Boxplots.



The Box plots show that on average the percentage of learners who know(Y) or have an idea(I) of the definition/meaning of the word has increased from 61% to 72% for the English and from 40% to 49% in maths. This shows that the intervention had a positive impact on learners' knowledge of the English and maths definitions of the chosen Ambiguous words. This means the intervention helped increase the proportion of learners who know or have an idea (Y+I) the English and maths definition/meaning of the words.

4.2.4 Association between English and Maths definition of a word, and answering a maths question

We wanted to know if there is an association between knowing the English and maths definitions/meaning of the ambiguous words and answering maths question based on those words. We used logistic regression where the response is a binary variable, where “1” is denoted if the learner correctly or partially answered the maths question and “0” if the learner has not answered the maths question or have given an incorrect answer. The predictors are knowing the English definitions and maths definitions or not.

We have considered five words and the maths questions based on those words and we have run five logistic regression models in the pre-diagnostic and five logistic regression models in the post-diagnostic. The outputs of the logistic regression models are given on table 4.2.4.1

Word	Pre-diagnostic output							
Compound			# Iter	20		Alpha	0.05	
		coeff	*s.e.*	*Wald*	*p-value*	*exp(b)*	*lower*	*upper*
	intercept	-0.7917635	0.2916624	7.369365	0.006634	0.453045		
	English-codes	0.428882472	0.4004306	1.147155	0.284145	1.535541	0.70051	3.365956
	maths-codes	-0.35517175	0.5062254	0.492254	0.482924	0.701053	0.259927	1.890822
Base			# Iter	20		Alpha	0.05	
		coeff	*s.e.*	*Wald*	*p-value*	*exp(b)*	*lower*	*upper*
	intercept	-1.35361	0.389213	12.09518	0.000506	0.258306		
	English-codes	0.439704	0.467724	0.883775	0.34717	1.552248	0.620631	3.882293
	Maths-codes	0.451592	0.442792	1.040141	0.307789	1.570811	0.659506	3.741359
Root			# Iter	20		Alpha	0.05	
		coeff	*s.e.*	*Wald*	*p-value*	*exp(b)*	*lower*	*upper*
	intercept	-2.6414094	0.5920958	19.90158	8.15E-06	0.071261		
	English-codes	0.60938946	0.5613948	1.178292	0.277704	1.839308	0.612061	5.52732
	Maths-codes	1.00601646	0.5571071	3.260865	0.070952	2.734686	0.917692	8.149253
Proportion			# Iter	20		Alpha	0.05	
		coeff	*s.e.*	*Wald*	*p-value*	*exp(b)*	*lower*	*upper*
	intercept	-3.5511286	0.7942	19.9928	7.773E-06	0.028692		
	English-codes	0.63144522	0.655737	0.927282	0.3355701	1.880326	0.520078	6.798255
	Maths-codes	1.66309432	0.806593	4.251331	0.0392196	5.27561	1.085674	25.63574
Similar			# Iter	20		Alpha	0.05	
		coeff	*s.e.*	*Wald*	*p-value*	*exp(b)*	*lower*	*upper*
	intercept	-0.72797	0.519076	1.966828	0.160785	0.482887		
	English-codes	1.51674	0.568376	7.121168	0.007618	4.557344	1.495924	13.88398
	Maths-codes	0.649318	0.453238	2.052402	0.151966	1.914235	0.787405	4.653635

Word	Post-diagnostic output							
Compound		# Iter		20		Alpha		0.05
		coeff	*s.e.*	*Wald*	*p-value*	*exp(b)*	*lower*	*upper*
	intercept	-1.22083	0.316994	14.83225	0.000118	0.294986		
	English-codes	0.507213	0.398524	1.619837	0.203115	1.660657	0.760423	3.626639
	Maths-codes	1.083934	0.394453	7.551175	0.005997	2.956288	1.364543	6.404808
Base		# Iter		20		Alpha		0.05
		coeff	*s.e.*	*Wald*	*p-value*	*exp(b)*	*lower*	*upper*
	intercept	-1.366759044	0.501389	7.430766	0.006412	0.254932		
	English Codes	0.580340973	0.513841	1.275586	0.258721	1.786648	0.652615	4.89126
	Maths codes	0.247075727	0.399646	0.382216	0.53642	1.280276	0.584957	2.802097
Root		# Iter		20		Alpha		0.05
		coeff	*s.e.*	*Wald*	*p-value*	*exp(b)*	*lower*	*upper*
	intercept	-2.82231186	0.73926008	14.575233	0.000135	0.059468		
	English-code	1.030517751	0.79823191	1.6666821	0.196704	2.802516	0.586262	13.3969
	Maths code	0.701471797	0.50166165	1.9552335	0.162024	2.016719	0.754449	5.39089
Proportion		# Iter		20		Alpha		0.05
		coeff	*s.e.*	*Wald*	*p-value*	*exp(b)*	*lower*	*upper*
	intercept	-2.56551354	0.463445	30.64452	3.1E-08	0.07688		
	English-codes	0.977961532	0.559538	3.054814	0.080498	2.65903	0.888063	7.961643
	Maths codes	0.660950387	0.53458	1.528663	0.216313	1.936632	0.679222	5.521826
Similar		# Iter		20		Alpha		0.05
		coeff	*s.e.*	*Wald*	*p-value*	*exp(b)*	*lower*	*upper*
	intercept	-1.93019	0.490176	15.50582	8.23E-05	0.145121		
	English-codes	-0.05209	0.490627	0.011271	0.915453	0.949247	0.362874	2.483144
	Maths-codes	1.368814	0.463579	8.71849	0.00315	3.930688	1.584416	9.751422

Table 4.2.4.1
The output above is summarised and interpreted in the table below.

English	Pre-diagnostic Test	Post-diagnostic Test
	Compound: No statistically Significant Association **Base:** No statistically Significant Association **Root**: No statistically Significant Association **Proportion:** No statistically Significant Association **Similar:** There is a statistically significant Association, learners who knew the English definition were approximately 4.5 times more likely to answer the maths question	**Compound:** No statistically Significant Association **Base:** No statistically Significant Association **Root:** No statistically Significant Association **Proportion**: No statistically Significant Association **Similar**: No statistically significant association
Maths	**Compound:** No statistically Significant Association **Base:** No statistically Significant Association **Root:** No statistically Significant Association **Proportion:** There is a statistically Significant Association, learners who knew the maths definition were approximately 5 times more likely to answer the maths question **Similar**: No statistically significant association	**Compound**: There is a statistically significant Association, learners who knew the maths definition were approximately 3 times more likely to answer the maths question **Base:** No statistically Significant Association **Root**: No statistically Significant Association **Proportion**: No statistically Significant Association **Similar:** There is a statistically significant Association, learners who knew the maths definition were approximately 4 times more likely to answer the maths question

Table 4.2.4.2

The data shows a significant association between knowing the maths definitions of the words similar, compound and proportion and answering the maths questions based on them. It's worth noting that the word proportion is the only word that had percentage of learners who know the maths and English definition decreased from pre diagnostic to post diagnostic. While the word compound was the word with the least percentage of learners who knew the maths definitions (21%) in the pre diagnostic. This shows that a statistically significant association between the words that learners are struggling with their definitions and answering the maths question.

4.2.5 The analysis of the follow up question

At the end of each maths question in the pre-diagnostic and post-diagnostic there was a follow up question with 5 categories (Table 4.2.5.1) that learners need to choose (see the pre diagnostic/post diagnostic). The responses for each category are found out across all learners and from all 15 questions of the pre-diagnostic and the 14 questions of the post-diagnostic. Then the percentage for each category is calculated in both pre-diagnostic and post-diagnostic (table4.2.5 2.).

Codes	Categories
1	I understood the question and I answered it.
2	I don't know what the question is asking me to do.
3	I can't do the calculation.
4	I don't know the mathematical meaning of the word.
5	I found the question hard for another reason.

Table 4.2.5.1

The percentage of learners who said they understood the question and answered it has increased which showed increased confidence although some of those learners might not have answered the question correctly. The percentage who said that they don't understand what the question is asking them to do (category 2) and the percentage who said they don't understand the mathematical meaning of the word (category 4) has decreased from 11% to 8% in category 2 and 9 % to 4% in category 4. This shows that the pre-teaching of the

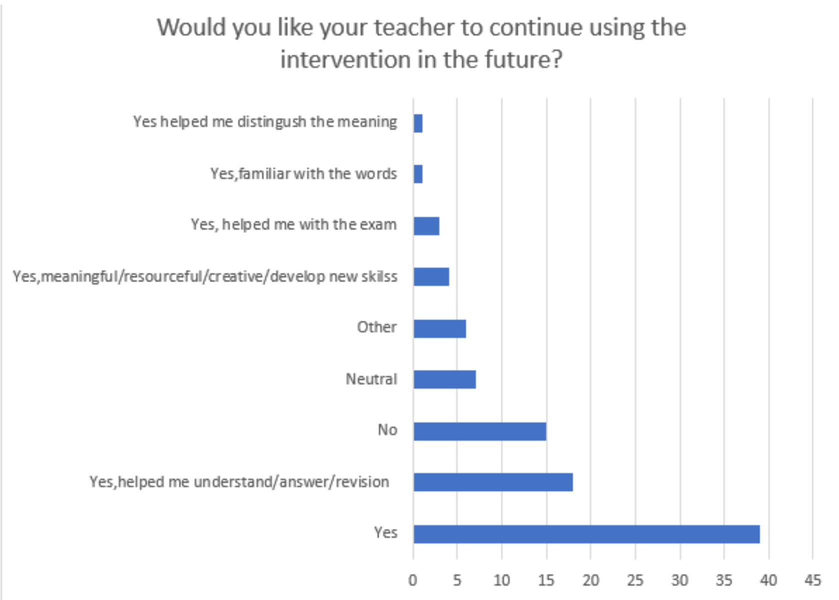
English and maths meaning of the ambiguous words at the start of the lesson and completing the heavily adapted Frayer model template at the end of the intervention lesson made a small positive impact on learner understanding.

Categories	Totals Pre-diagnostic	% Pre-diagnostic	Totals Post-diagnostic	% Post-diagnostic
1	**1054**	62%	1215	66%
2	185	11%	152	8%
3	220	13%	207	11%
4	162	9%	79	4%
5	89	5%	41	2%
Blank/ two or more choices	0	0	154	8%

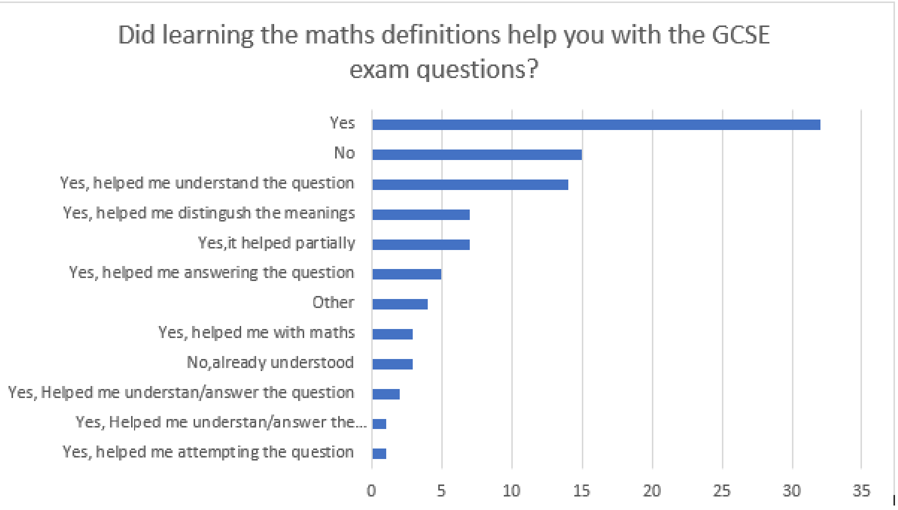
Table 4.2.5.2

4.3. Post Intervention Student Questionnaire Analysis

The aim of the learner questionnaire was to evaluate how they found the interventions and its impact on improving understanding of maths questions in context. Then, those responses were exhaustively analysed by the team and appropriate codes were assigned.



70% of learners said that they would like their teacher to continue using the intervention in the future. Whereas 16% said that they didn't want to.



77% of learners said that learning the mathematic definitions did help them understand the GCSE exam questions. Whereas 19% said that it didn't help them

When students were asked if completing the word template helped them to understand the maths topic better, 69% of them answered that they either agreed or strongly agreed. Whereas 5% of students either disagreed or strongly disagreed.
When students were asked if the use of the word template helped them to distinguish the English meaning and the mathematical meaning of the words, 78% of them answered that they either agreed or strongly agreed. Whereas 3% of students strongly disagreed.

4.4. Teachers' reflections

The final step for this project was to grasp teachers' experience of having gone through this intervention. Therefore, a questionnaire was collated using MS Forms where teachers were asked to express how each stage of the intervention impacted their teaching and consequently, their students' progress. The result is summarised here

- All teachers agreed to positive change in student understanding and improved post-intervention outcome
- Improvement in discussion and understanding
- Some teachers think that there was improvement in students' approach to problems and most teachers recognised students' improved use of vocabulary.
- Some teachers acknowledged improvement in ESOL/non ESOL behaviour for learning and most teachers believe there was improvement in concept understanding
- Most teachers have indicated change in behaviour to include vocabulary as part of the lesson focus.
- All teachers agree they will use this intervention in the future

4.5 Overall discussion

The analysis shows that mean scores of all learners have increased from pre to post. The mean scores of learners who completed both tests have seen and statistically significant increase, this coupled with the fact that on average the percentage of learners who know or have an idea of the English and maths definitions of words have increased shows the effectiveness of the intervention. A surprise result was that ESOL learners did better than the non-ESOL in both pre and post-diagnostic tests. This could be because these learners have strong technical background compared to the non-ESOL.

After the intervention we have also observed an increase in the proportion of the correct definitions given by the learners, and this might have caused an increase in the post diagnostic scores. Developing a learner's mathematical register provides them with analytical, descriptive, and problem-solving skills within a language and a structure through which they can explain a wide range of experiences (Ní Ríordáin, Coben, & Miller-Reilly, 2015: page 13)

There was significant association between knowing the maths definitions of the words proportion and compound and answering the maths questions based on these words. But on the other hand, the analysis of the definition showed a decrease the percentage of learners who know the English and maths definitions of the word "Proportion", while the percentage of learners who know the maths definition of the word compound has increased from 21% in the pre-diagnostic to 40% in the post-diagnostic.

The fact that that most learners reported that the intervention helped them with their GCSE exam questions coupled with the fact that teachers observed improved discussion and understanding of maths shows that once learners know the meaning of the words that is being used then this in turn will help them to do well in the maths questions, in fact As Durkin and Shire (1991) state: "Mathematics education begins in language, it advances and stumbles because of language, and its outcomes are often assessed in language.''

5.Conclusions and Recommendations

5.1. Conclusions

- On average the percentage of learners who know or have an idea of the English definition/meaning and maths definition/meaning for each word and the proportion of the correct definitions/meaning has increased after the intervention.

- ESOL/EAL and non ESOL/EAL learners scores on average have improved after the intervention. This shows both cohorts benefited from the intervention.

- ESOL learners did better than the non ESOL in both the pre diagnostic and post diagnostic. This mean that ESOL learners in this cohort may have strong technical background compared to the non ESOL.

- The intervention had positive impact on learners and most learners said that learning maths definition/meaning helped them with their GCSE exam questions and want their teachers to continue using the intervention in the future. This would suggest that the intervention has helped learners not only to recall and recognise the maths terminology but also to distinguish the English meaning and the Maths meaning of these ambiguous words.

- The analysis suggests the pre-teaching of the words and completion of the adapted Frayer model style template had an impact on increasing scores and learning the definition/meaning of the words. There are also other factors that can have an impact on the result.

- Data is based on a set of maths questions and a cohort of learners in Newham college and findings can't be generalised

5.2. Recommendations

- For us in Newham, we will continue to use the teaching techniques used in the in the interventions.

- We embedded the use of the "heavily adapted Frayer model" in our Scheme of Work for next academic year.

- When teaching the vocabulary, we need to include the non-ESOL, because they benefited from the interventions in the language of mathematics.

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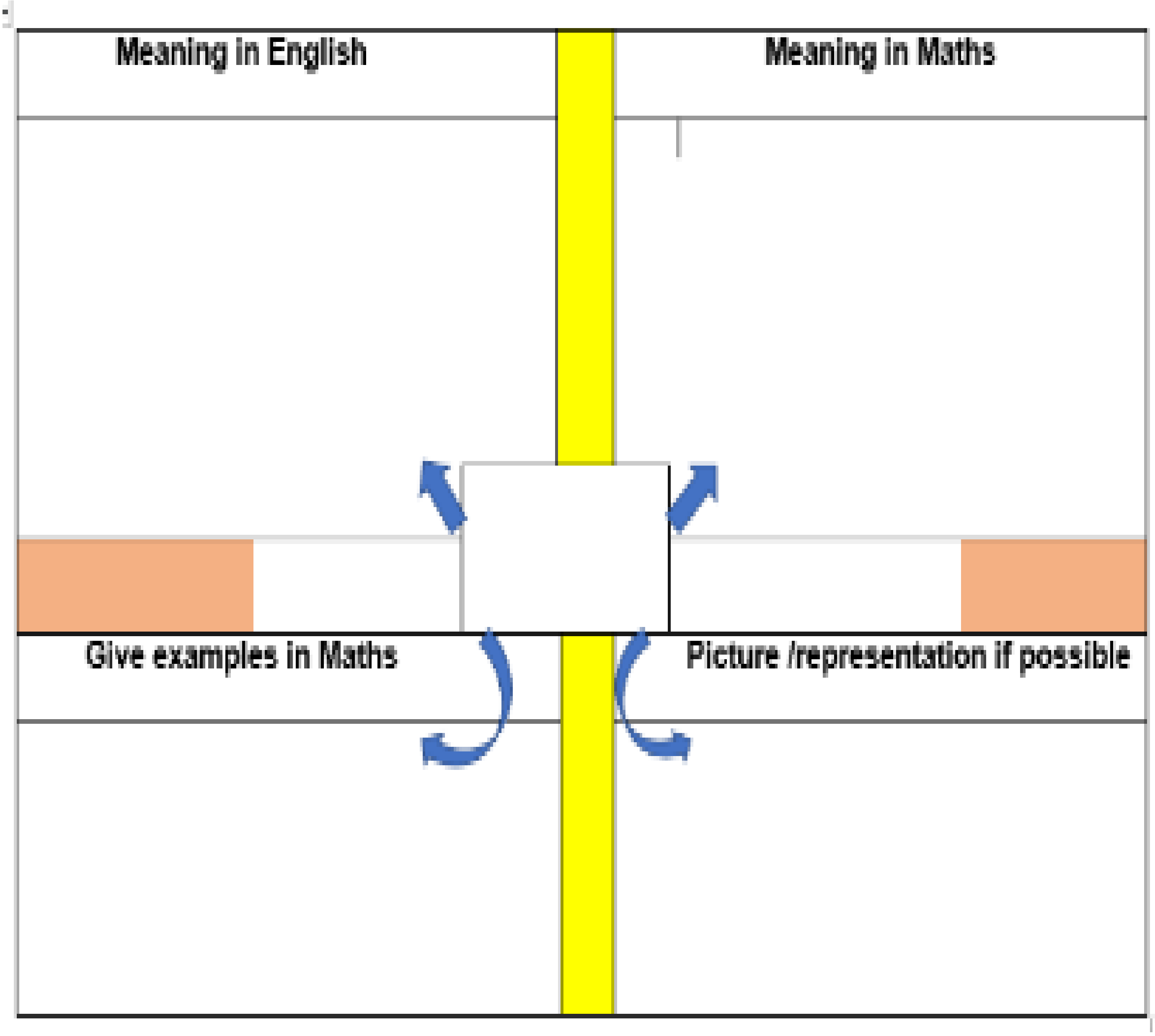
Appendices

Appendix A : Heavily adapted Frayer model



Appendix B: Padlet

Appendix C: Language Questionnaire

Questionnaire about language and mathematics 20/21

Please answer the following questions:

1. Please write your name and ID number in the box below: *

Enter your answer

2. I have studied in the UK since the age of: *

Enter your answer

3. Do you consider English to be your first language? *

- Yes
- No

4. How many languages do you speak? *

Enter your answer

6. Please select the option that applies to you: *

- I am doing GCSE English now
- I am doing Functional skills English now
- I am not studying English

7. If you are not studying English, please tell us why in the box below:

Enter your answer

8. Language is a barrier to my learning of mathematics, please tick the one that applies to you *

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

+ Add new

Appendix D: Pre Diagnostic Assessment

Expression

1
Define "Expression" in everyday language. *

Enter your answer

2
Define "Expression" in mathematics. *

Enter your answer

3
Which one of these is an Expression? *

- a
- $3x+5y=6$
- $5b+3y$ ✓
- $2x+y=4(x+2)$
- I don't know

4
Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- I don't know the mathematical meaning of the word
- I found the question hard for another reason

5
If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

Compound

16
Define "Compound" in everyday language. *

Enter your answer

17
Define "Compound" in mathematics. *

Enter your answer

18
Which of these is a compound shape. *

- L-Shape ✓
- Triangle
- Square
- Circle
- I don't know

19
Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- I don't know the mathematical meaning of the word
- I found the question hard for another reason

20
If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

Expand

6
Define "Expand" in everyday language. *

Enter your answer

7
Define "Expand" in mathematics. *

Enter your answer

8
Expand $4(3x-2)$ *

Enter your answer

9
Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- I don't know the mathematical meaning of the word
- I found the question hard for another reason

10
If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

21
Which of these are compound measures *

- Area
- Density ✓
- Temperature
- Pressure ✓
- I don't know

22
Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- I don't know the mathematical meaning of the word
- I found the question hard for another reason

23
If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

24
Charlie invests £1200 at 4% per annum compound interest.

Work out the value of Charlie's investment after 2 years. *

Enter your answer

25
Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- I don't know the mathematical meaning of the word
- I found the question hard for another reason

26
If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

Estimation

11
Define "Estimation" in everyday language. *

Enter your answer

12
Define "Estimation" in mathematics. *

Enter your answer

13
Use estimation to find the value of $8.3+1.69$ *

Enter your answer

14
Regarding the pervious question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- I don't know the mathematical meaning of the word
- I found the question hard for another reason

15
If you found the question hard for another reason, please tell us why in the box below.

Base

27
Define "Base" in everyday language. *

Enter your answer

28
Define "Base" in mathematics. *

Enter your answer

29
What is the base of x^3 *

Enter your answer

30
Regarding the previous question choose the one that applies to you *

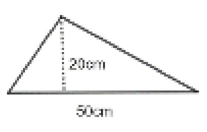
- I understood the question and I answered it
- I don't understand what the question is asking me to do
- I can't do the calculation
- I don't know the mathematical meaning of the word
- I found the question hard for another reason

31
If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

32

What is the base of this triangle *



Enter your answer

33

Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- I don't know the mathematical meaning of the word
- I found the question hard for another reason

34

If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

Root

35

Define "Root" in everyday language. *

Enter your answer

36

Define "Root" in mathematics. *

Enter your answer

37

Calculate the square root of 64 *

Enter your answer

38

Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- I don't know the meaning of the word
- I found the question hard for another reason

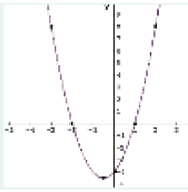
39

If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

40

Which points are the roots of the graph *



Enter your answer

41

Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- I don't know the mathematical meaning of the word
- I find the question hard for another reason

42

If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

Reflection

43

Define "Reflection" in everyday language. *

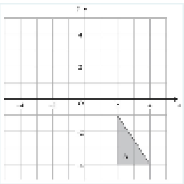
Enter your answer

44

Define "Reflection" in mathematics. *

Enter your answer

45



triangle A is reflected in the x-axis, what are the new coordinates of its corners. *

Enter your answer

46

Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- Don't know the mathematical meaning of the word
- I found the question hard for another reason

47

If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

Proportion

48

Define "Proportion" in everyday language. *

Enter your answer

49

Define "Proportion" in mathematics. *

Enter your answer

50

A concrete mixer contains 5kg of cement and 15kg of sand. What is the proportion of sand in the mixture? *

Enter your answer

51

Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- I don't know the mathematical meaning of the word
- I found the question hard for another reason

52

If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

53

The ratio of males to females in a class is 4:5. What proportion of females are in the class? *

Enter your answer

54

Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- I don't know the mathematical meaning of the word
- I found the question hard for another reason

55

If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

Similar

56

Define "Similar" in everyday language. *

Enter your answer

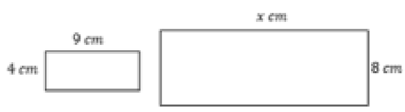
57

Define "Similar" in Mathematics. *

Enter your answer

58

The two rectangles are similar.
What is the length marked x? *



Enter your answer

59

Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- Don't know the mathematical meaning of the word
- I found the question hard for another reason

60

If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

Translate

61

Define "Translate" in everyday language. *

Enter your answer

62

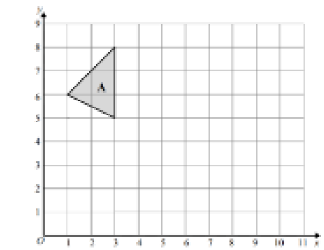
Define "Translate" in Mathematics. *

Enter your answer

63

Please answer the question below. *

Triangle A is translated by $\begin{pmatrix} 5 \\ -3 \end{pmatrix}$, what are the new coordinates of its corners?



Enter your answer

64

Regarding the previous question choose the one that applies to you *

- I understood the question and I answered it
- I don't know what the question is asking me to do
- I can't do the calculation
- I don't know the mathematical meaning of the word
- I found the question hard for another reason

65

If you found the question hard for another reason, please tell us why in the box below.

Enter your answer

66

Please write your name and ID number in the box below: *

Enter your answer

+ Add new

Appendix E – Post Intervention Diagnostic Test

Language Action Research

Post intervention Diagnostic Test

Centre for Excellence in Maths: Newham College

April 2021

1. Expression

a) Give the definition/meaning of the word “Expression” in everyday language

b) Give the definition/meaning of the word “Expression” in mathematics

c) Apples cost 25p each. Bananas cost 20p each. The total cost of *a* apples and *b* bananas is C. Write a formula for the total cost of *a* apples and *b* **bananas.**

d) Regarding the question c) please tick the one that applies to you

I understood the question and I answered it

I don’t know what the question is asking me to do

I can’t do the calculation

I don’t understand the meaning of the word

If you found the question hard for another reason tell us why
…………………………………………………………………..

2. Expand

a) Give the English definition/meaning of the word “Expand” in everyday language

b) Give the definition/meaning of the word “Expand” in Mathematics

c) Expand 3(7x – y)

d) Regarding the question c) please tick the one that applies to you

I understood the question and I answered it

I don’t know what the question is asking me to do

I can’t do the calculation

I don’t understand the meaning of the word

If you found the question hard for another reason tell us why……………………………………………………

3. Estimation

a) Give the definition/meaning of the word “Estimation” in everyday language

b) Give the definition/meaning of the word “Estimation” in Mathematics

c) Stuart buys 72 packets of crisps at 19p each. Estimate the total cost.

d) Regarding the question c) please tick the one that applies to you

I understood the question and I answered it

I don’t know what the question is asking me to do

I can’t do the calculation

I don’t understand the meaning of the word

If you found the question hard for another reason tell us why……………………………………………………..

4. Compound

a) Give the English definition/meaning of the word “Compound” in everyday language

b) Give the definition/meaning of the word “Compound” in mathematics

c) Which one of these are not compound measures, please circle the correct answer/s

i) Speed ii) Area iii) Density iv)Pressure v) Perimeter vi) I don’t know

d) Regarding the question c) please tick the one that applies to you

I understood the question and I answered it

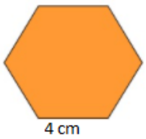
I don’t know what the question is asking me to do

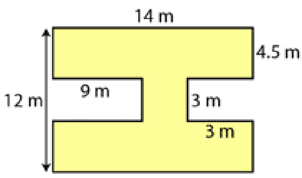
I can’t do the calculation

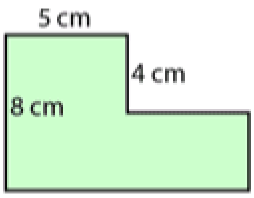
I don’t understand the meaning of the word

If you found the question hard for another reason tell us why

e) Which ones of these are compound shapes? Please tick the correct answers







f) Regarding the question e) please tick the one that applies to you

I understood the question and I answered it

I don’t know what the question is asking me to do

I can’t do the calculation

I don’t understand the meaning the word

If you found the question hard for another reason tell us why

g) Charlie invests £1600 at 5% per annum compound interest.

Work out the value of Charlie's investment after 4 years.

h) Regarding the question g) please tick the one that applies to you

I understood the question and I answered it

I don't know what the question is asking me to do

I can't do the calculation

I don't understand the meaning the word

If you found the question hard for another reason tell us why

5. Base

a) Give the definition/meaning of the word "Base" in everyday language

b) Give the definition/meaning of the word "Base" in mathematics

c) What is the base of x^6.

d) Regarding the question c) please tick the one that applies to you

I understood the question and I answered it

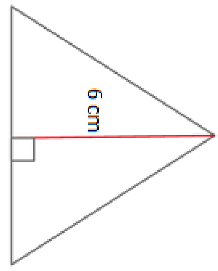
I don't know what the question is asking me to do

I can't do the calculation

I don't understand the meaning of the word

If you found the question hard for another reason tell us why

e) The height of this triangle is 6.0 cm.



Label the base of the triangle

f) Regarding the question e) please tick the one that applies to you

I understood the question and I answered it

I don't know what the question is asking me to do

I can't do the calculation

I don't understand the meaning of the word

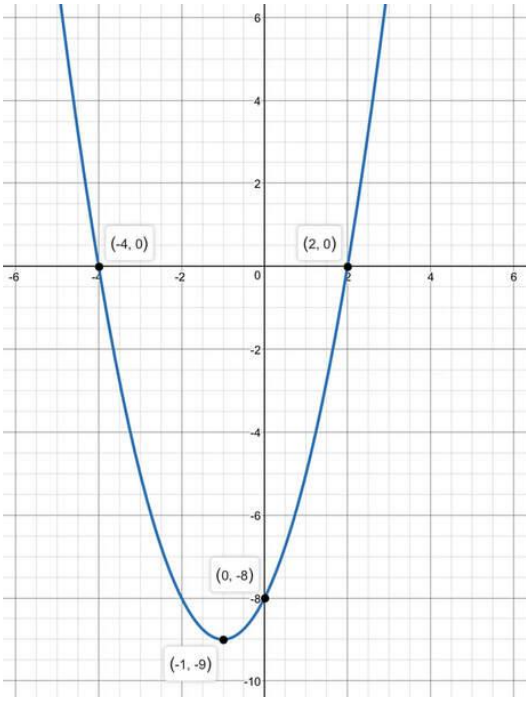
If you found the question hard for another reason tell us why

6. Roots

a) Give the English definition/meaning of the word "Root" in everyday language

b) Give the definition/meaning of the word "Root "in mathematics

c) **What are the roots of the graph below**



d) Regarding the question c) please tick the one that applies to you

I understand the question and I answered it

I don't know what the question is asking me to do

I can't do the calculation

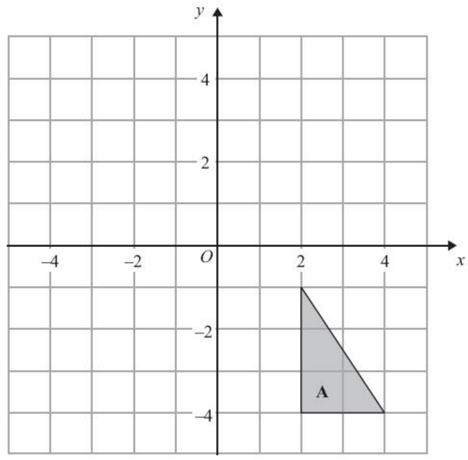
I don't understand the meaning of the word

If you found the question hard for another reason tell us why

7. Reflection

a) Give the English definition/meaning of the word "Reflection" in everyday language

b) Give the definition/meaning of the word “Reflection” in mathematics



c) Reflect triangle A in the y-axis.

d) Regarding the question c) please tick the one that applies to you

I understood the question and I answered it

I don’t know what the question is asking me to do

I can’t do the calculation

I don’t understand the meaning of the word

If you found the question hard for another reason tell us why

8. Proportion

a) Give the English definition/meaning of the word “proportion” in everyday language

b) Give the definition/meaning of the word “proportion” in mathematics

c) **A concrete mixer contains 7kg of cement and 28kg of sand. What is the proportion of sand in the mixture?**

d) Regarding the question c) please tick the one that applies to you

I understood the question and I answered it ☐

I don't know what the question is asking me to do ☐

I can't do the calculation ☐

I don't understand the meaning of the word ☐

If you found the question hard for another reason tell us why

e) **The ratio of males to females in a class is 7:5. What proportion of females are in the class?**

f) Regarding the question e) please tick the one that applies to you

I understood the question and I answered it ☐

I don't know what the question is asking me to do ☐

I can't do the calculation ☐

I don't understand the meaning of the word ☐

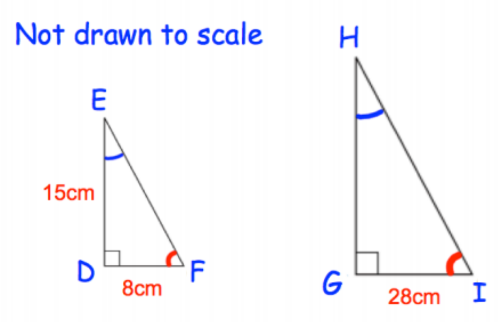
If you found the question hard for another reason tell us why

9. Similar

a) Give the definition/meaning of the word "Similar" in everyday language

b) Give the definition/meaning of the word "similar" in mathematics

c)



DEF and GHI are similar right angled triangles.
DE = 15cm
DF = 8cm
GI = 28cm

Workout the length of HG

d) Regarding the question c) please tick the one that applies to you

I understood the question and I answered it

I don't know what the question is asking me to do

I can't do the calculation

I don't understand the meaning of the word

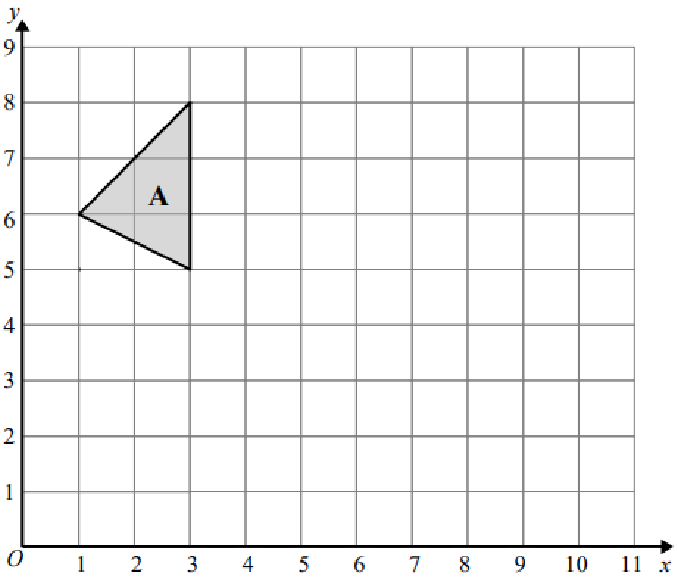
If you found the question hard for another reason tell us why

10. Translation

a) Give the English definition/meaning of the word “Translation” in everyday language

b) Give the definition/meaning of the word “Translation” in Mathematics

c)



Translate triangle **A** by the vector $\begin{pmatrix} 5 \\ -3 \end{pmatrix}$

d) Regarding the question c) please tick the one that applies to you

I understood the question and I answered it ☐

I don't know what the question is asking me to do ☐

I can't do the calculation ☐

I don't understand the meaning of the word ☐

If you found the question hard for another reason tell us why

Appendix : F Post Intervention questionnaire for students

1

Name and ID number *

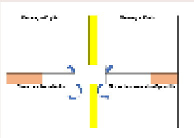
Enter your answer

2

Did you attend at least one of the 5 lessons when your teacher delivered the intervention lessons based on the English definitions and the Maths definitions of the following words; (Expression, Expand, Estimate, Compound, Base, Roots, Proportion, Reflection, Similar, Translate) *

- Yes
- No

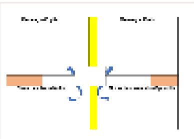
3



In the lessons you attended, have you completed the word templates either on Whiteboard.fi or on paper?. Overall how many words have you completed them for? *

- 0
- 1-4
- 5-7
- 8-10

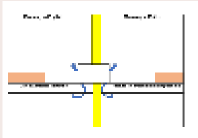
4



Completing the word template helped me understand the maths topics better *

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

5



The use of the word template helped me distinguish the English meaning and the maths meaning of the words *

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

6

I find it easier completing the word template on *

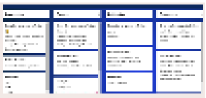
- Whiteboard.fi
- Paper in class

7

Explain why you have chosen your answer in question 6 *

Enter your answer

8



The completion of Padlet at the begining of the lessons supported me in learning English and Maths definitions of the words *

- strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

9

Knowing the English definition/meaning of words helped me understand the mathematics topics more? *

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

10

Knowing the Maths definition/meaning of words helped me understand the mathematics topics more? *

- Strogly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

11

Did learning the English definition/meaning of words help you understand GCSE exam questions better? If yes, how did it help? *

Enter your answer

12

Did learning the Maths definition/meaning of words help you understand GCSE exam questions better? If yes, how did it help? *

Enter your answer

13

Would you like your teacher to continue using the intervention (teaching the English definitions/meaning and Maths definitions/meaning of maths words, completing the word template) in future lesson? Explain why? *

Enter your answer

+ Add new

Appendix G :Teacher Reflections

Teacher Reflections- Language AR

1. Has students' understanding of the maths topics improved after you have taught these words? Please give examples

Enter your answer

2. What impact has completing the intervention activities had on your students' performance in their maths lessons? Give examples

Enter your answer

3. To what extent do you think that students have improved their usage of the mathematical language covered by the interventions? Please elaborate on your answer.

Enter your answer

4. How different types of learners(ESOL/NON ESOL) responded in using this intervention? how was the progress of different types of learners. Give examples

Enter your answer

5. Have you changed your teaching because of the project?

Enter your answer

6. How did you find completing the interventions face-to-face vs online? Comment on any differences

Enter your answer

7. Will you be using the intervention in the future?

Enter your answer

8. If you have any other relevant feedback or comments, please write them here?

Enter your answer

Appendix H: Collaboratively planned PowerPoint

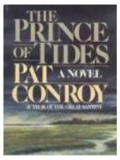
Base: Meaning in English

The lowest part or edge of something, especially the part on which it rests or is supported.

"she sat down at the base of a tree"

Use (something specified) as the foundation or starting point for something.

"the film is based on a novel by Pat Conroy"

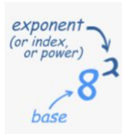


Base: Meaning in Mathematics

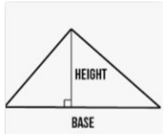
The number that gets multiplied when using an exponent.

Examples:

- in 8^2, 8 is the **base**, and the result is $8 \times 8 = 64$.
- in 5^3, 5 is the **base**, and the result is $5 \times 5 \times 5 = 125$.



The **base of a triangle** is any one of the sides, and the height of the **triangle** is the length of the altitude from the opposite vertex to that **base**



Examples:

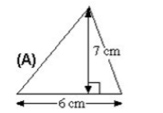
1) Find the values of:

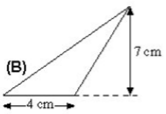
$3^3 =$ ____

$2^4 =$ ____

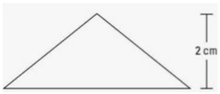
$8^2 =$ ____

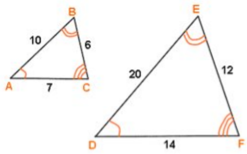
2) Find the area of these triangles





3) This triangle has area 8 cm². The height is 2 cm.
Find the base of the triangle:





Meaning of "similar" in maths

Definition 1:

Two shapes are similar if they are having the same shape but not necessarily the same size. The corresponding angles within the shapes are equal.

Definition 2:

If one shape can become another using resizing, then the shapes are **Similar.**

Meaning of "similar" in English

Definition 1:

We use similar if two or more things are not entirely the same.

Example: Frank had a problem connecting his printer. We had a similar problem, so it must be the software

Not: … a same problem …

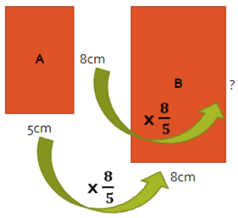
Definition 2:

Looking or being almost, but not exactly, the same

Example: Paul is very similar in appearance to his brother.

Using scale factors to calculate length

E.g. 1 Shape A and B are mathematically similar.
Calculate the missing length



Let x = scale factor

$5x = 8$

$x = \frac{8}{5}$

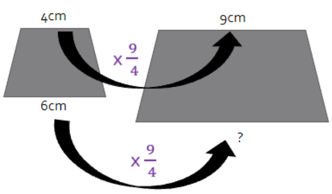
$8 \times \frac{8}{5} = \frac{64}{5}$

$= 12\frac{4}{5}$

$= 12.8$cm

Using scale factors to calculate length

E.g. 2 Shape A and B are mathematically similar.
Calculate the missing length



Let x = scale factor

$4x = 9$

$x = \frac{9}{4}$

$6 \times \frac{9}{4} = \frac{54}{4}$

$= \frac{27}{2}$

$= 13.5$cm