2019

Survey Analysis Report

UPPER PRIMARY REPORT

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The Republic of Ghana, located in west Africa, is home to multiple ethnic groups and tribal languages. According to World Education News and Reviews (Kamran, Liang and Trines, 2019) there are approximately 50 indigenous languages spoken in Ghana and the Bureau of Ghana Languages lists approximately 34 spoken Ghanaian languages. English, the official language of government, is the language of instruction for schools and universities (Kamran, Liang and Trines, 2019). Overtime there have been several changes to the government recognized language of instruction, ranging from no Ghanaian languages being used in the schools from 1957 to 1966 to the current language policy implemented in 2002 (Adika, 2012). In 2002, English was designated as the language of instruction for all of education from primary 1 through university (Adika, 2012), however there was an amendment made in 2004 which allowed for the children's mother tongue to be used up to primary three (Anyidoho, 2018).

In the capital, Accra, Ga is the indigenous language of the region, however due to migration from the rural areas for employment opportunities, there is diversity in the population both ethnically and linguistically (Anyidoho, 2018). The school classes in Accra, being an urban hub of Ghana, will have a linguistic population which is considered heterogeneous (Adika, 2012). Adika (2012) states, "Also, in the rural areas the concept of homogeneity does not really exist, and the linguistic situation is not uncomplicated" (p.155). The lack of homogenous classrooms can prove difficult for both teachers and students.

Mathematics is considered a language in itself, however knowledge of language is important when learning mathematics, and it becomes more important when the student is learning both English and mathematics simultaneously (Bresser, 2018). Bresser (2018), highlights the challenges which are present when teaching ELL students, one being teaching mathematics vocabulary, such as explaining polysemous words and the second challenge highlighted is for teachers to both teach conceptual knowledge alongside with academic language.

Turkan (2016) reflects on research stating that there is lack of information regarding what knowledge is needed for mathematics teachers in an English Language Learners (ELL) classroom. In order to gain more information about what knowledge teachers in an ELL environment a research study was designed to investigate current ELL teachers' knowledge and beliefs. The study explores mathematics teaching in English by Ghanaian upper primary teachers. One hundred and twenty-one teachers participated in piloting the survey of 50 questions, consisting of three types of questions: closed, free response, and problem solving. The purpose of the study was to investigate:

1. What are teacher beliefs regarding the nature of mathematics?
2. What is their pedagogical knowledge of teaching English learners?
3. What are their beliefs regarding teaching math to English learners?

Methods

<u>Survey Development</u>

A survey was created in two sections. The first section consisted of three constructs focused on: teacher pedagogical knowledge about teaching mathematics, teacher beliefs about the nature of mathematics, and teachers' beliefs on teaching English learners. The second section investigated teachers' knowledge (content and pedagogical) of mathematics by having the respondents correct a sample of students work.

Section one. Items for section one of the survey were designed to gather demographic data on teachers, and the following constructs; their pedagogical knowledge about teaching mathematics, their beliefs about the nature of mathematics, and their understandings about teaching math to English learners. The items in this section were demographic (descriptive), ranking, Likert scale, rating scale, yes/no questions and open-ended questions.

Demographic information. Part one of the survey was created to investigate participants demographics, including education and language proficiencies. For language proficiencies it was important to investigate their perceived English levels as well as their mother tongue skills. In addition to the teachers' knowledge of English and mother tongue language, because of the unique language diversity in Ghana, information regarding the spoken Ghanaian language of their students and the Ghanaian language taught in their schools was gathered.

Teacher pedagogical knowledge about teaching mathematics. These questions were designed to measure teacher pedagogical knowledge of mathematics as well as their pedagogical knowledge of teaching mathematics to English language learners. Questions were free response, Likert scale and yes/no measuring what participants believed: determined high quality instruction, was important for pupils to do in class, assessment strategies and their knowledge of polysemous mathematical vocabulary.

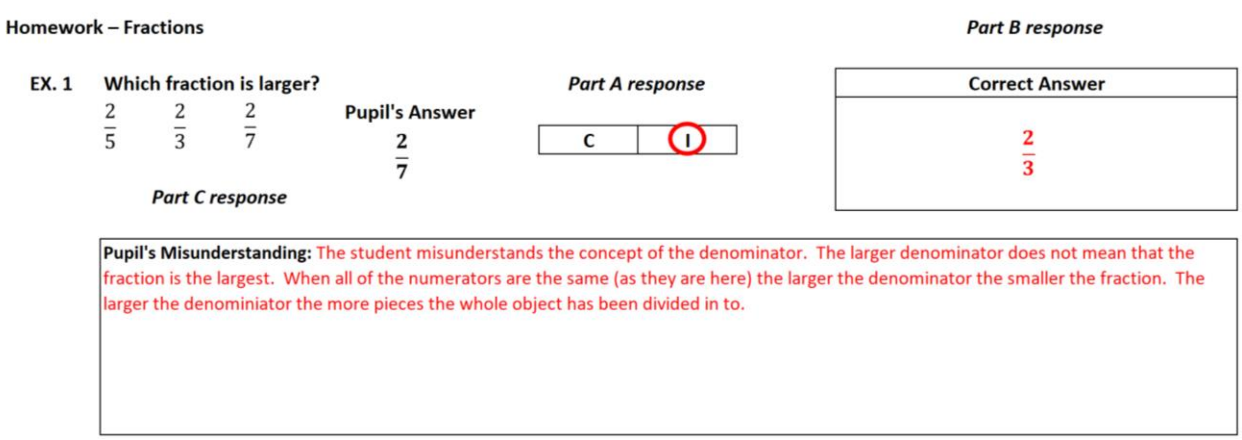
Teacher beliefs about the nature of mathematics. The questions designed to measure this construct utilized Likert scale, and free response. They measured participants beliefs regarding what is needed to be successful in mathematics, regarding what they thought about mathematics as a subject and its integration with the real – world.

Teachers' beliefs on teaching English learners. These questions were designed to measure teachers' beliefs on the teaching English language learners in general and in mathematics. The questions were Likert scale, yes/no and free response. They measured how the participants interact with the English language learners in their classrooms as well as their language usage in their mathematics classes to assist students in understanding.

Section two. Items in section two comprised of two scenarios which explored teacher's content and pedagogical knowledge of mathematics, and their ability to identify the nuances of English which students might struggle with during mathematical problem solving.   Participants were expected to do the following for both scenarios:

1. Mark if a student's response to a question was correct or incorrect
2. If the student's response is incorrect, the respondent should give the correct answer in the space provided.
3. If the student's response is incorrect, the respondent should explain the 'Pupil's Misunderstanding'.

The questions in scenario one consisted of addition and subtraction of fractions with common and uncommon denominators. Both topics are taught in grades three and four according to the Ghana mathematics curriculum (2012). The questions in scenario two would be part of the Money unit from the Ghanaian mathematics curriculum primary 3 through primary 6, including concepts of purchasing items and change. The last word problem was a concept of division, which is covered from primary three, remainders and estimation, and knowledge of mathematics vocabulary from primary four and five. All three problems contained polysemous words which can cause ELL problems when solving. Due to the inconsistency in the participants responses within each question, each part was analyzed separately to preserve as many results as possible. In the example three responses are expected from the participant. Some participants may have given a response to Part A and Part B and **not** Part C, or Part B and Part C and **not** Part A, etc.


Homework – Fractions

Part B response

EX. 1 Which fraction is larger? $\frac{2}{5}$ $\frac{2}{3}$ $\frac{2}{7}$

Pupil's Answer $\frac{2}{7}$

Part A response

C	I

Correct Answer
$\frac{2}{3}$

Part C response

Pupil's Misunderstanding: The student misunderstands the concept of the denominator. The larger denominator does not mean that the fraction is the largest. When all of the numerators are the same (as they are here) the larger the denominator the smaller the fraction. The larger the denominiator the more pieces the whole object has been divided in to.

Survey Validation

Pre-test and Group Debriefing. After developing the survey items, a mathematics education expert examined the survey to ensure face validity. The feedback offered verified that the questions in the first section as well as the problem-solving questions were considered at the correct level for the grade levels being investigated and investigated variables which addressed the research questions. The concerns pertained to the length of the survey because of a common issue of survey fatigue. Aligning with the feedback, two questions were removed from the problem-solving section of the survey to reduce the time needed to complete the survey. Next, researchers validated the instrument with teachers in in the Greater Accra Region of

Ghana. Validation of the instrument consisted of a pre-test and group debriefing to determine whether the items were clearly articulated, if respondents answered the questions correctly and to assess any confusion regarding certain items on the survey. The pre-test survey was administered to 15 respondents. After the pre-test, the survey administrators conducted individual or group debriefing with the respondents.
Questions respondents were asked included:

- How much time did it take teachers to complete the survey?
- How did teachers respond to being told the purpose of the assessment?
- How did teachers receive the task of evaluating fictitious student mathematics problems?
- Were the terms used in the directions and items understood by the teachers?
- Was there any confusion as to how to answer the items?
- Was there any obvious redundancy in the survey items?

Following the feedback on the group debriefing the survey items considered to be redundant were deleted from section one, along with two questions from the section two. Some questions which initially requested for the respondents to rank items in order where changed to a Likert scale. Questions which required respondents to rank order were changed to Likert scale items. In this way, the final number of questions was shortened from 50 to 46. Some questions have multiple parts, therefore when looking at individual items the original instrument had 231 items and after the debriefing the number of items was reduced to 198 items.

Survey question reduction by sections					
	Original Instrument		Instrument after reduction		
	Questions	**Items**	**Questions**	**Items**	**% Item Reduction**
Part A	40	199	39	181	9.2%
Part B	10	32	7	17	46.9%
Total	50	231	46	198	14.3%

Data Collection

The pilot was conducted with 121 upper primary teachers teaching in forty-eight schools comprising two rural and forty-six urban schools. Paper surveys were administered to teacher participants.

Participants

There were fifteen demographical questions gathering information about the 121 participants. The most notable results of the demographic data demonstrated that the majority (96%) of the teachers taught in an urban school, 65% of the teachers were less than 40 years of age, and 59% held a bachelors degree or higher. The average years of teaching experience was 10.5, with 56% having less than 10 years in the classroom.

Participants Education and Teaching Experience

Aheto-Tsegah (2011) states a challenge for schools in Ghana is the lack of trained primary school teachers, especially in the rural communities, however this was not as evident for our sample of teachers. The participants ranged in classroom experience from half a year to forty-one years. Approximately 48% had a post-secondary major in a STEM subject or Education. However, over half had completed college courses in methods of teaching mathematics and primary school mathematics content courses. This indicates the majority of these teachers, should have both the conceptual and pedagogical knowledge for teaching mathematics.

Language

Classroom and School Language

The official language of the Ghanaian government is English, however, according the Bureau of Ghana Languages there are approximately 11 government sponsored languages and 25 non-government sponsored languages. When analyzing the participants, the Ashanti local language was the most widely spoken when teaching mathematics (64%), followed by Akuapem (14%). Even with the Ashanti local language being the most widely spoken, Ga was the most widely taught in the respondents' schools.

Ashanti may be most used local language in the classroom it is aligned with the 68% of the pupils that speak the language in the classroom. A little over half (51.2%) of the teachers' mother tongue is the same local language as what most pupils in their class speak. The local language the pupils speak is not necessarily their mother tongue, it could be that they are using the teacher's mother tongue or what is spoken by their peers.

Q10. Local languages used when teaching mathematics		
	n	**%**
Ashanti	77	64%
Akuapem	17	14%
Ewe	2	2%
Fante	12	10%
Ga-Adangbe	14	12%
Guan	0	0%
Mole-Dagbon	0	0%
Other	5	4%

Q11. Ghanaian Languages taught in the school		
	n	**%**
Adangbe	0	0%
Akuapem	53	44%
Asante Twi	50	41%
Bono	0	0%
Dagbani	0	0%
Ewe	10	8%
Fanti	3	2%
Ga	69	57%
Gonja	0	0%
Hausa	0	0%
Kokomba	0	0%

Q12. Ghanaian Languages most Pupils speak

	n	%
Adangbe	1	1%
Akuapem	37	31%
Asante Twi	82	68%
Bono	0	0%
Dagbani	2	2%
Ewe	15	12%
Fanti	6	5%
Ga	43	36%
Gonja	0	0%
Hausa	6	5%
Kokomba	1	1%

Q13. Ghanaian Language considered teacher's mother tongue		
	n	**%**
Adangbe	3	2%
Akuapem	13	11%
Asante Twi	46	38%
Bono	3	2%
Dagbani	0	0%
Ewe	20	17%
Fanti	14	12%
Ga	11	9%
Gonja	1	1%
Hausa	3	2%
Kokomba	0	0%

It is noticeable that the language most spoken by the students and the mother tongue of the teachers is not the language which is taught in schools, nor the language of instruction, English. Primary students have seen improved educational outcomes when taught in their mother tongue (Seid, 2016) and it appears that many of the students and teachers would have the same mother tongue, Asante Twi 68% and 38% respectively.

Teacher Language Proficiency

The respondents of the survey all teach upper primary grades consisting of grades four, five and six. During these grades, according to the language policy in Ghana, students transition to primary education in English, and all subjects including mathematics are taught in this language. Respondents were asked to assess their level of both their mother tongue and English language proficiency in reading, speaking, listening and writing. They were to choose their proficiency as '*Needs Work', 'Good', 'Very Good', or 'Excellent'*. When analyzing the results, the scale was given a numerical value from 1 to 4 in order to determine how the respondents view their own language skills.

For their mother tongue language proficiencies, the averages for each skill were between 2.4 and 3.3. Speaking and Listening were the highest rated with 75% of the respondents rating themselves as *'Very Good' or 'Excellent'*. Writing was the lowest rated with 56% of the respondents placing themselves as either *'Needs Work' or 'Good'*.

Overall, for their English language proficiencies the averages were between 3.2 and 3.4 with a standard deviation between 0.7 and 0.8 and approximately 25 % of the respondents ranked themselves as *'Needs Work' or 'Good'*. With 59% of the participants having received a bachelor's degree or higher they have studied in English during their higher education studies.

Each skill was analyzed to determine if there was a relationship between their mother tongue and English language proficiencies. There was a very weak positive correlation between the respondents' mother tongue and English language skills. The highest relationship was found for listening with only a correlation $r = 0.58299$, yet still considered weak.

Q14. Mother Tongue Proficiency n = 115

	Reading	Speaking	Listening	Writing
Needs Work	15	2	1	25
Good	37	21	21	39
Very Good	33	34	34	28
Excellent	30	58	59	23
NULL	0	0	0	0

Q15. English Proficiency n = 115

	Reading	Speaking	Listening	Writing
Needs Work	3	1	1	3
Good	12	13	13	17
Very Good	40	54	47	48
Excellent	60	47	54	47
NULL	0	0	0	0

Averages and Standard Deviation

	Reading	Speaking	Listening	Writing
Averages	2.678261	3.286957	3.313043	2.426087
Std Dev	1.004794	0.824677	0.79874	1.04345

Averages and Standard Deviation

	Reading	Speaking	Listening	Writing
Averages	3.365217	3.278261	3.33913	3.208696
Std Dev	0.776072	0.695194	0.711891	0.789133

Relationship between the languages by skill set.

	Reading	Speaking	Listening	Writing
Correlation	0.264499	0.410319	0.582999	0.338489

Based on the educational preparation of the participants (highest educational attainment, post-secondary major and the completed teacher college courses) the majority should have both the content and pedagogical knowledge to teach mathematics to upper primary students. They also reported a high level of English proficiency, therefore it could be inferred the participants are prepared to teach mathematics in English. Analysis of the remaining survey will demonstrate if Ghanaian teachers are prepared to integrate their skill sets to teach ELL students mathematics.

Data Analysis

The quantitative data was coded defining all variables on the research instrument and entered in an Excel spreadsheet. The qualitative data, the open-ended questions from both sections as well as the participants solutions to the word problems were also entered into the Excel spreadsheet for each question as the respondents wrote it.

Prior to analysis, the data was cleaned by looking for anomalies such as the number of unanswered responses (in total and per question), responses that were not answered as intended, and/or items that had very low response rates. 47% of the participants completed all items on the instrument, therefore when individual questions were analyzed the number of responses for that question is given as, '*n=*'. One question, asking participants to rank items in order from 1 – 9 using each number only once, was removed from use in the analysis due to only 50 (41.3%) of the respondents' answering correctly.

Section one of the survey had seven qualitative responses (free responses), not including the name of the respondents' school, there was an average response rate of 90% (9 to 19 respondents did not answer a question or part of a question.) The remaining thirty-one questions are coded as quantitative responses and the average response rate per question was approximately 99% (0 to 7 respondents did not answer a question or part of a question.)

Section two of the survey had the respondents correcting students work, there were both quantitative and qualitative responses. There were five quantitative responses with an average response rate of 85% (10 to 27 respondents did not answer a question.) For the qualitative responses, the average response rate was 70% (11 to 80 respondents did not answer a question.) Each question was analyzed separately to ensure the maximum number of participants could be included in the analysis.

Analysis was conducted using Excel to find descriptive statistics, ANOVA single factor test, regression analysis and correlations. To ensure reliability of the responses for each question or item, XLSTAT (in Excel) was used to find the Cronbach's alpha to ensure consistency between the items. A Cronbach's alpha greater than or equal to 0.7 is considered to have an acceptable level of consistency. For items determined to be consistent (reliable), the single factor ANOVA was run to determine if significance was found between the items. Significance is determined if the F statistic is greater than the F critical. When significance is seen, individual variables were analyzed to find which item in particular may be a catalyst. A regression analysis was used to determine which individual item is significant with a p-value less than 0.05. The p-value of the correlations between questions regarding teaching English language learners was calculated using XLSTAT. The correlations which yielded a p-value < 0.05 were determined to be significant.

Excel was used to investigate the qualitative demographic questions, and the free response questions in both sections one and two. In section one the participants were asked to write what they considered to be good teaching, how they would introduce a new topic and how they would explain differences between the English and mathematical definitions for polysemous words. The responses were grouped by to create categories with a common theme. Once categories were created, frequencies and percentages were obtained for each response and relationships between the qualitative variable and another item in the survey.

Results

The results for the study are presented as evidence towards answering the to the three research questions. Analysis and results are given for the items with demonstrated internal reliability. A discussion regarding interpretations of the results as well as relationships between several questions or items follows.

The Cronbach alpha values tested for internal validity on questions with multiple items are listed in the table.

Four of the five questions displayed a Cronbach's alpha greater than or equal to 0.69, and a standardized Cronbach's alpha of 0.71 or greater, therefore all the items within those questions are consistent hence reliable. The one which is 0.678, has nine items within the question. Three (33%) of the questions can lead to a response which is on the 'Strongly Disagree' to 'Disagree' side of the Likert scale, therefore the lower alpha. However, even with the lower alpha can still be considered internally reliable.

What are teacher beliefs regarding the nature of mathematics?

The National Council for Teachers of Mathematics (NCTM,2019) states that teachers have a direct effect on how their students understand skills and concepts, how they use those skills and concepts to solve problems and the confidence they have when solving problems. Teachers need to have a strong foundation in their own content knowledge as well as various pedagogical skills. According to Stipek, Givvin, Salmon and MacGyvers (2001) there is a direct relationship between teacher's beliefs have a direct effect on their classroom practices and students learning experience.

There were two questions (fifteen items) within section one analyzed for teacher's beliefs regarding the nature of mathematics. Each question was measured using a Likert scale using 0 to 3 representing 'Strongly Disagree' to 'Strongly Agree' respectively. The questions investigated participants agreement with:

1. What pupils need to be good at mathematics, and

2. Nine general statements about mathematics.

The results for individual items follow in the tables along with the ANOVA results.

1. *The teachers' beliefs on what pupils need to be successful in mathematics.*

The question had 116 respondents and 91% or more 'Agree' or 'Strongly Agree' with the statements. The average of each idea was between 2.4 and 2.6. Based on the results of the respondents, fundamentally all their beliefs are aligned with the NCTM's principles of teaching mathematics. All respondents, which answered, agreed it is important for pupils to 'Understand mathematical concepts, principles and strategies', and approximately 95.7% agreed it is important to 'Understand how mathematics is used in the real world'.

33	**To be good at mathematics at school, to what extent do you agree or disagree that it is important for pupils to… Check one box in each row.**	**Strongly disagree**		**Disagree**		**Agree**		**Strongly agree**	
a.	Remember formulas and procedures	2	2%	6	5%	45	39%	63	54%
b.	Think in a step-by-step logical order	0	0%	4	3%	47	41%	65	56%
c.	Understand mathematical concepts, principles, and strategies	0	0%	0	0%	39	34%	77	66%
d.	Be able to think creatively	0	0%	10	9%	49	42%	57	49%
e.	Understand how mathematics is used in the real world	0	0%	5	4%	53	46%	58	50%
f.	Be able to provide reasons to support their solutions	0	0%	4	3%	55	47%	57	49%

The p-value = 0.016238 < 0.05 for the group and the F statistic is larger than the F critical therefore there is significance between the variables.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Remember formulas and procedures	116	285	2.456897	0.458996
Think in a step-by-step logical order	116	293	2.525862	0.321064
Understand mathematical concepts, principles, and strategies	116	309	2.663793	0.225112
Be able to think creatively	116	279	2.405172	0.417016
Understand how mathematics is used in the real world	116	285	2.456897	0.337256
Be able to provide reasons to support their solutions	116	285	2.456897	0.319865

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4.856322	5	0.971264	2.802653	0.016238	2.227087
Within Groups	239.1207	690	0.346552			
Total	243.977	695				

The average of the items' averages was 2.49. Four of the six items had averages below the overall average, however only one, 'Be able to think creatively' was considerably lower than all averages. This caused the researcher to investigate further as to what variables could influence the participants response. The table displays the demographics of the participants which gave the lowest scores.

Demographic of participants belief of what is important for pupils to be good at mathematics	
	Be able to think creatively (2.41)
Lowest score given	1
Number of respondents giving the lowest score	10
Minimum of Years Teaching	2
Maximum Years teaching	27
STEM major	3
Education major	3
College Course - Method of teaching mathematics	3
College Course - Mathematics content for primary school mathematics	4

This question had the highest rate of consensus for what was 'Agreed' and 'Strongly Agreed' upon.

The item with the lowest average was for pupils to 'Be able to think creatively.' Lince (2016) compiled various definitions from research, regarding creative thinking in mathematics, and concluded "...the creative thinking of students were able to come up with ideas or ideas, make decisions and make generalizations" (p. 208).

a. The range for the years of experience was from 2 – 27.
b. 60% of the participants who responded with 'Disagree' were either STEM or Education majors.
c. 70% of the participants have taken the college courses; method of teaching mathematics and or mathematics content for primary school.

Švecová, Rumanová, and Pavlovičová (2014) concluded their research on mathematical thinking stating a main goal of education is to encourage creative and logical thinking as well as problem solving. Based on this statement, the research investigated further and determined that 60% of participants who disagreed with believing it is important for pupils to think creatively, incorrectly answered 'Farmer's Total' and 'Akua's Money Left' of the word problems in scenario two and 90% missed the last word problem 'Minimum number of Teams'. Teachers are unable to correctly apply the creative thinking to solve the word problems, therefore an assumption could possibly be made that they might be unable implement creative thinking in their teaching.

2. *<u>Teachers agreement to nine statements regarding mathematics.</u>*

There were 114 participants who responded to this question. The average for the items ranged from 1.23 to 2.39. This question had the lowest Cornbach's alpha and did not meet the minimal 0.7 which is considered reliable. Two of the items lent themselves to receiving a 'Strongly Disagree' or 'Disagree'. The statements 'Mathematics is primarily an abstract subject' and 'Basic computational skills on the part of the teacher are sufficient for teaching elementary school mathematics' had the highest percent of response receiving a 0 or 1 rating with 72% and 32%. These results cause the items to appear as if they are not consistent.

34	To what extent do you agree or disagree with each of the following statements? Check one box in each row.	Strongly disagree		Disagree		Agree		Strongly agree	
a.	Mathematics is primarily an abstract subject.	25	22%	47	41%	33	29%	9	8%
b.	Mathematics is primarily a formal way of representing the real	2	2%	16	14%	72	63%	24	21%
c.	Mathematics is primarily a practical and structured guide for	1	1%	11	10%	67	59%	35	31%
d.	If pupils are having difficulty, an effective approach is to give them	2	2%	11	10%	57	50%	44	39%
e.	Some pupils have a natural talent for mathematics and others do	5	4%	21	18%	37	32%	51	45%
f.	More than one representation (picture, concrete material, symbol	3	3%	7	6%	46	40%	58	51%
g.	Mathematics should be learned as sets of rules that cover all	3	3%	20	18%	60	53%	31	27%
h.	Basic computational skills on the part of the teacher are sufficient	4	4%	28	25%	54	47%	28	25%
i.	Knowing pupils is essential for teaching mathematics.	4	4%	10	9%	50	44%	50	44%

The F statistic is greater than the F critical and the p – value = 7.46 E -33 < 0.05 implying significance.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Mathematics is primarily an abstract subject.	114	140	1.22807	0.779382
Mathematics is primarily a formal way of representing the real world.	114	232	2.035088	0.423537
Mathematics is primarily a practical and structured guide for addressing real situations.	114	250	2.192982	0.404906
If pupils are having difficulty, an effective approach is to give them more practice by themselves during the class.	114	257	2.254386	0.492237
Some pupils have a natural talent for mathematics and others do not.	114	248	2.175439	0.783108
More than one representation (picture, concrete material, symbol set, etc.) should be used in teaching a mathematics topic.	114	273	2.394737	0.52422
Mathematics should be learned as sets of rules that cover all possibilities.	114	233	2.04386	0.555581
Basic computational skills on the part of the teacher are sufficient for teaching elementary school mathematics.	114	220	1.929825	0.6322
Knowing pupils is essential for teaching mathematics.	114	260	2.280702	0.593076

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	107.1014	8	13.38767	23.22346	7.46E-33	1.947491
Within Groups	586.2719	1017	0.576472			
Total	693.3733	1025				

The four of the twelve (33%) items which had an average below 2.06 (the average of the averages) were investigated further. The demographics of the participants for these four items are in the table.

Demographic of participants belief of what is important for pupils to be good at mathematics				
	Mathematics is primarily an abstract subject. (1.23)	**Mathematics is primarily a formal way of representing the real world. (2.04)**	**Mathematics should be learned as sets of rules that cover all possibilities. (2.04)**	**Basic computational skills on the part of the teacher are sufficient for teaching elementary school mathematics. (1.93)**
Lowest score given	0	(0) 1	(0) 1	(0) 1
Number of respondents giving the lowest score	25	(2) 18	(3) 21	(4) 30
Minimum of Years Teaching	1	(4) 2	(18) 1	(1) 1
Maximum Years teaching	36	(19) 34	(33) 29	(19) 32
STEM major	7	(0) 7	(0) 9	(0) 8
Education major	4	(0) 3	(1) 2	(0) 7
College Course - Method of teaching mathematics	20	(2) 13	(2) 15	(2) 19
College Course - Mathematics content for primary school mathematics	17	(1) 12	(2) 13	(1) 16

Three of the four (75%) items identified with the lowest averages (1.23, 1.93, and 2.04) infer that they Strongly Disagree with the statements and in principle this is a positive ideology for the level of mathematics they may be familiar.

a. The Oxford definition of mathematics is “the abstract science of number, quantity, and space, either as abstract concepts (pure mathematics), or as applied to other disciplines such as physics and engineering (applied mathematics).” Zazkis and Liljedahl (2002) state that “Patterns are the heart and soul of mathematics.” And they continue by discussing the progression from concrete to generalization (abstract algebraic thinking.) Therefore, the assumption could have been made that thought more participants would ‘Agree’ or ‘Strongly Agree’ with this statement.
b. 72% of the participants responded ‘Agree’ or ‘Strongly Agree’ (47 and 25% respectively) that basic computational skills are enough to teach elementary mathematics.

There were forty-six pairs between the items which showed significance with a p – value, 0.05. The table shows the pairs in bold.

p-values (Pearson): Variables which demonstrate significant a relationship. P - value < 0.05

Variables	Q33a	Q33b	Q33c	Q33d	Q33e	Q33f	Q34a	Q34b	Q34c	Q34d	Q34e	Q34f	Q34g	Q34h	Q34i
Q33a	**0**														
Q33b	**< 0.0001**	**0**													
Q33c	**< 0.0001**	**0.004**	**0**												
Q33d	**0.000**	**< 0.0001**	**0.000**	**0**											
Q33e	**0.001**	**< 0.0001**	**0.003**	**< 0.0001**	**0**										
Q33f	**0.006**	**< 0.0001**	**0.000**	**< 0.0001**	**< 0.0001**	**0**									
Q34a	0.218	0.095	0.898	0.841	0.101	0.887	**0**								
Q34b	0.991	0.449	0.255	0.065	0.129	0.116	0.428	**0**							
Q34c	0.432	0.142	0.775	**0.012**	0.167	0.131	0.761	**< 0.0001**	**0**						
Q34d	0.455	**0.013**	0.060	0.081	**0.007**	**< 0.0001**	0.142	**0.045**	0.419	**0**					
Q34e	0.960	0.172	0.715	0.772	0.917	0.304	**0.019**	0.059	**0.010**	0.888	**0**				
Q34f	0.072	0.395	0.145	0.780	0.608	0.626	0.564	**< 0.0001**	**0.000**	0.321	**0.033**	**0**			
Q34g	0.695	0.990	0.859	0.224	0.269	0.835	**0.040**	**< 0.0001**	**< 0.0001**	0.408	**< 0.0001**	**0.001**	**0**		
Q34h	0.873	0.510	0.937	0.947	0.419	0.975	0.808	**0.002**	**0.001**	0.739	**0.012**	**0.000**	**< 0.0001**	**0**	
Q34i	**0.001**	**0.002**	**0.004**	**0.001**	**0.001**	**0.006**	0.943	**0.009**	**0.016**	0.066	**0.039**	0.086	**0.004**	0.210	**0**

The most significance are between the items within the same questions. The items which were significant between the two questions were:

		To be good at mathematics at school, to what extent do you agree or disagree that it is important for pupils to… Check one box in each row.					
		Remember formulas and procedures	Think in a step-by-step logical order	Understand mathematical concepts, principles, and strategies	Be able to think creatively	Understand how mathematics is used in the real world	Be able to provide reasons to support their solutions
To what extent do you agree or disagree with each of the following statements? Check one box in each row.	Mathematics is primarily an abstract subject.						
	Mathematics is primarily a formal way of representing the real world.						
	Mathematics is primarily a practical and structured guide for addressing real situations.				X		
	If pupils are having difficulty, an effective approach is to give them more practice by themselves during the class.		X				X
	Some pupils have a natural talent for mathematics and others do not.					X	
	More than one representation (picture, concrete material, symbol set, etc.) should be used in teaching a mathematics topic.						
	Mathematics should be learned as sets of rules that cover all possibilities.						
	Basic computational skills on the part of the teacher are sufficient for teaching elementary school mathematics.						
	Knowing pupils is essential for teaching mathematics.	X	X	X	X	X	X

<u>What is their pedagogical knowledge of teaching mathematics to English learners?</u>

Robertson (2019) discusses the importance of language when teaching mathematics to English Language Learners (ELL) and her findings which emphasized, "language acquisition, building background knowledge, increasing student language production, and explicitly teaching academic language." When asked if the respondents thought it was important for pupils to "Learn vocabulary to help understand math concepts", 98.2% 'Agreed' or 'Strongly Agreed', demonstrating some awareness of the importance of teaching vocabulary to the population of students they teach.

The survey asked both closed and open questions to gauge teacher pedagogical knowledge of teaching English learners. Robertson (2019) discussed several strategies for teaching mathematics to ELL students and one was explaining polysemous words explicitly to ELL students.

The first open or free response questions focused on polysemous words and asked, "How would you explain the differences between the general English word even and the mathematical term even?"

1. *Explain the differences between the general English word even and the mathematical term even.*

There were 107 participants who responded by giving definitions. The word 'even' is polysemous, with the English definition being flat or smooth, uniform or equal in number, amount or value or same. In addition to these definition for even, the adverb, used to emphasize something extreme or surprising, was also included as correct. Whereas the mathematics definition for even means a number divisible by two without a remainder (number $= 2n$). There were 107 participants (88.4%) who responded to the question. The word and concept of 'even' is taught in grade four, according the Ghana Mathematics Curriculum (2012), therefore it would be expected that there would be a higher percentage of correct mathematics definitions. This is borne out by the data. Although more than half of the teachers were able to define the general English word, more of them (78.5%) were able to define the mathematical meaning. The conclusion from this suggest that a teacher would be able to explain the mathematical meaning of the word 'even' to the students.

Polysemous Word 'Even'		
	n	**%**
Correct English	73	68.22%
Correct Math	84	78.50%

Examples of the participants correct and incorrect responses for the polysemous word 'Even'

	Correct	**Incorrect**
English	*Uniform*	*Eglish is how to a proper words in expression of speaking*
	Even in English means uniform	*Fair*
	Something that is uniform or level	*English even means greater in degree*
Mathematics	*As in even numbers; ie numbers divisible by 2 without a remainder*	*mathematics is about our daily life activities*
	in mathematics means a set of numbers that can be divided exactly by two without a remainder	*A certain kind of numbers*
	Number that is divisible by two	*Mathematical term even means equal in numbers*

2. *Explain the differences between the general English word product and the mathematical term product.*

There were 111 participants giving their definitions. The English definition is an article or substance that is manufactured or refined for sale and in mathematics it is the quantity or result obtained from multiplication. If the respondent gave the mathematics definition as multiplication of figures or multiplication of numbers, this was incorrect. The 'product' is the result of multiplication not multiplication itself. The word and concept of 'product' is taught in grade two, according to the Ghana Mathematics Curriculum (2012), therefore it would be expected that more than 44% of the respondents would have given the correct mathematics definitions.

Polysemous Word 'Product'		
	n	**%**
Correct English	99	89.19%
Correct Math	49	44.14%

Examples of the participants correct and incorrect responses for the polysemous word 'Product':

	Correct	**Incorrect**
English	*What we get by processing raw material,*	*In language, English often put non-materials words as subject.*
	An action of a result of something of a process	*Goes with letter*
		Profit of something
Mathematics	*The result of multiplying two numbers*	*Multiplication*
	The result of multiplying numbers	*Goes with numbers*
		Product means result
		Sum of two numbers

In conclusion since the teachers struggled to define this word it is reasonable to assume that participants would have difficulty teaching this word or explaining the differences to a student.

A similar free response question asked, 'In what ways do you help pupils learn mathematics vocabulary?' Twenty-three overall responses out of the 112 respondents, with some variation of "explaining the vocabulary" being the most frequent answer. Using Robertson (2019) and Chard's (n.d.) strategies stated as effective in teaching mathematics, the two common themes (in Italics) were used as categories along with emerging common themes from the responses.

Chard's strategies for teaching vocabulary	Robertson's strategies for teaching vocabulary
1. *Pre-teach mathematics vocabulary* 2. *Model vocabulary when teaching new concepts* 3. Use appropriate labels clearly and consistently 4. Integrate vocabulary knowledge in assessments.	1. Demonstrate that vocabulary can have multiple meanings. 2. Encourage students to offer bilingual support to each other. 3. *Provide visual cues, graphic representations, gestures, realia, and pictures* 4. *Identify key phrases or new vocabulary to pre-teach.*

Themes n = 112	n	%
Use visual representations, concrete objects etc.	11	9.821429%
Pre-teach new vocabulary in the upcoming lesson (find the definition of the word, creating vocabulary cards and/or sheets)	22	19.64286%
Teach the vocabulary in context of the mathematics topic	26	23.21429%

Teach spelling, diction and pronunciation	11	9.821429%
Repetition, make a review	3	2.678571%
Explaining	35	31.25%
Other (category had less than 2 mentions and did not fit a Theme)	5	4.464286%

The most common result (31.25%) of 'explaining' is a vague answer to the question of "In what ways do you help pupils learn mathematics vocabulary?" Explaining could take on various methods and could encompasses all themes, based on what the participant meant. For this reason, it was separated out as its own category.

Based on the results from the respondents, after '*explaining'* the highest themes were, *'Teach the vocabulary in context of the mathematics topic*' and '*Pre-teach new vocabulary in the upcoming lesson'* with 23.2% and 19.6 % respectively.

Interestingly only 11 respondents stated that visual representations and concrete objects were important in teaching vocabulary, yet this is a well-known strategy recommended for teaching English learners. Researchers, curriculum developers and teacher educators (Robertson, 2019, Sandoval, 2018, Chard, n.d.) all include modeling mathematics vocabulary with objects, pictures, graphs, etc. Only 11 respondents stated that they taught spelling, dictation and pronunciation. This finding supports the literature which states that mathematics teachers rarely teach literacy skills such as spelling and writing because they do not see it as their role.

The next free response question was, "What are some of the challenges you have in teaching mathematics in English?" resulted in 50.9% (n=55) of the respondents answered *'language'* as their main challenge when teaching.

Theme n=107	**n**	**%**
Language	55	50.92593
Resources	15	13.88889
Understanding	4	3.703704
Word Problems	5	4.62963
No Challenges	12	11.11111
Students Behavior/Motivation	6	5.555556
*Reason unclear	8	7.407407
Other	2	1.851852

The themes 'Understanding', and 'Word Problems' could be considered part of 'language' however they did not specify language as some of the other respondents had therefore, it was separated out.

A similar question, closed, was asked earlier in the survey regarding the biggest challenges faced when teaching mathematics in their school. There were five challenges for the participants to choose from and they were similar to the responses in the free response question, however the impact of the challenge on the classroom differed in ranking between them. For the closed response question, 'Class Resources' was the biggest challenge reported by the respondents, however 'Language' was the biggest challenge reported in the free response question.

Free Response (Q 39)			Closed (Q 17)		
Theme n=108	**n**	**%**	**n=120**	**n**	**%**
Language	55	50.92593	Pupil Motivation	43	35.83333
Resources	15	13.88889	Teacher Resources	55	45.83333
Understanding	4	3.703704	Level of Teacher Math knowledge	15	12.5
Word Problems	5	4.62963	Class Resources	61	50.83333
No Challenges	12	11.11111	Low English of pupils	50	41.66667
Students Behavior/Motivation	6	5.555556			
*Reason unclear	8	7.407407			
Other	2	1.851852			

When offered choices to describe their teaching challenges, teacher responses indicate the biggest challenges were Class Resources and Teacher Resources with 51% and 46% respectively. Unlike when the respondents were able to write their own challenges, the biggest challenges were Language followed by resources with 52% and 14% respectively.

Even with resources having the highest response for the closed question, the teachers indicated that language was still a high challenge. This response led the researcher to further analyze the participants responses to their perception of the pupils' language proficiency and if the teachers would use the pupils' mother tongue in the class to assist in their understanding.

The responses of the 29 participants which responded 'Low English of the pupils' or 'language' for both the closed and open question respectively.

a. The participants rated, from 1 (beginning) to 4 (advanced) their pupils' English reading, writing and speaking skills. The results are shown in the table.

35	Rate each of the following, from 1 (beginning) to 4 (advanced), on how well *most* of the pupils you teach can do the following in English.	Rate 1 Beginning		Rate 2		Rate 3		Rate 4 Advanced		Null	
	a. Understand basic words and phrases	2	7%	9	31%	12	41%	5	17%	1	3%
	b. Understand simple sentences	5	17%	4	14%	9	31%	10	34%	1	3%
	c. Understand spoken language with ease	4	14%	9	31%	11	38%	4	14%	1	3%
	d. Use simple words to describe familiar things	3	10%	5	17%	10	34%	10	34%	1	3%
	e. Communicate about tasks, topics and routines	2	7%	7	24%	15	52%	3	10%	1	3%
	f. Describe events, experiences and feelings in detail in conversations	2	7%	7	24%	16	55%	3	10%	1	3%
	g. Identify memorized words	2	7%	11	38%	8	28%	6	21%	1	3%
	h. Read very short simple texts	5	17%	6	21%	10	34%	7	24%	1	3%
	i. Read and understand grade level texts fluently	3	10%	8	28%	11	38%	6	21%	1	3%
	j. Write short simple sentences	4	14%	8	28%	9	31%	7	24%	1	3%
	k. Write connected text on familiar topics	3	10%	13	45%	11	38%	1	3%	1	3%
	l. Write clear detailed connected texts on a variety of topics	2	7%	10	34%	15	52%	1	3%	1	3%

The respondents rated the majority of their pupils as 2 or 3. The only two items which has had a high percentage rating of 4 was for pupils' 'Understanding simple sentences' and 'Use simple words to describe familiar things' (34% and 34% respectively.) In order to solve word problems in mathematics, pupils should have strong reading and comprehension skills. Thirty-eight percent of the respondents rated the pupils 2 for 'Identify memorized words', even though they rated the pupils 3 for 'Read and understand grade level texts fluently'.

b. The participants responded regarding several language strategies they used to teach mathematics.

23	I speak pupils home languages in class while teaching to help them understand mathematics concepts. (Circle one)	Never		At least 25% of the time		At least 50% of the time		At least 75% of the time		Always		No Response	
		2	7%	3	10%	8	28%	11	38%	4	14%	1	3%

24	Pupil Participation / Engagement: (In English)	YES		NO		NULL	
	e. I encourage pupils to draw/use pictures, graphs, tables	25	86%	4	14%	0	0%

25	Pupil Participation / Engagement: (In Mother Tongue)	YES		NO		NULL	
	c. I take time to teach mathematical vocabulary to help pupils understand	28	97%	1	3%	0	0%
	d. I teach English grammar to help pupils understand mathematics concepts	18	62%	11	38%	0	0%
	e. I use pictures, graphs, tables or charts to help pupils understand word	27	93%	2	7%	0	0%

52% of the teachers finding the English language of the pupils as their biggest challenge also responded that they speak the pupils' home language in the class at least 75% of the time. 25% of the teachers, when using English, and 93% of teachers when using the pupils' mother tongue, encouraged the pupils to use drawings, pictures, graphs and tables, a strategy suggested for teaching ELLs.

The lowest positive response (62%) was seen for teaching English grammar to help pupils understand mathematics concepts, which further supporting literature stating mathematics teachers rarely teach literacy skills.

In conclusion if teachers are having difficulty teaching due to the pupils' English proficiency, especially identifying memorized words, they need to spend more time teaching literacy skills and speak to pupils in their home language to help them understand the mathematics concepts.

There were three closed questions (31 items) within section one analyzed for teacher's beliefs regarding the teaching mathematics measured using a Likert scale using 0 to 3 representing 'Strongly Disagree' to 'Strongly Agree' respectively. The questions investigated respondents:

1. Comfort level with nine aspects of mathematics and teaching mathematics,

2. Belief of what is important for pupils to do in class and

3. Frequency they use certain strategies when teaching a topic.

1. *Comfort level with nine aspects of mathematics and teaching mathematics (Q.16)*

There were 108 participants that responded to this question. Participants responded on a Likert scale from 0 to 3 implying 'Not Comfortable' to 'Very Comfortable'. The researchers gave a percentage range for the respondents to use to attempt to maintain consistency in the ordinal scale. The mean for the respondents' comfort level was between 2.12 and 2.59, meaning that they were at least comfortable with each specific aspect. The number of respondents for expressing their levels of comfort for each item is displayed in the table as n (%).

16	How comfortable are you:	Not comfortable		Somewhat comfortable		Comfortable		Very comfortable	
		0%		1 - 25%		26 - 75%		76 - 100%	
a.	Teaching mathematics at the primary grade level(s) you teach	0	0%	4	4%	36	33%	68	63%
b.	Teaching mathematics with other subjects	4	4%	10	9%	51	47%	43	40%
c.	Providing mathematics instruction that meets national mathematics content standards	0	0%	15	14%	51	47%	42	39%
d.	Using a variety of assessment strategies	0	0%	14	13%	46	43%	48	44%
e.	Teaching problem-solving strategies	1	1%	9	8%	51	47%	47	44%
f.	Teaching mathematics with manipulatives such as counting blocks (bottle caps) or geometric shapes	1	1%	9	8%	32	30%	66	61%
g.	Teaching a class of pupils with differering mathematical ability	0	0%	22	20%	46	43%	40	37%
h.	Teaching mathematics in English	1	1%	7	6%	46	43%	54	50%
i.	Teaching mathematics to pupils of differing levels of English proficiency	4	4%	18	17%	47	44%	39	36%

To determine if the items were significant within the question, ANOVA was run to determine the p-value. The variance for the second variable is greater than the first therefore the F statistics is valid. The results showed the F – statistic is larger than the F-critical and the p-value =0.00000133 < 0.05 therefore there is significance between the variables, and further investigation to determine which items have the greatest impact.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Teaching grade you teach	108	280	2.592593	0.318449
Teaching math with other subjects	108	241	2.231481	0.590775
Math Instruction to Natl curriculum	108	243	2.25	0.469626
Using variety of assess strategy	108	250	2.314815	0.479405
Teaching problem solving strategies	108	252	2.333333	0.448598
Teaching math with manipulatives	108	271	2.509259	0.476549
Teaching nonhomogeneous mathematics class	108	234	2.166667	0.551402
Teaching Math in English	108	261	2.416667	0.432243
Teaching math to pupils of varying English	108	229	2.12037	0.667619

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	21.107	8	2.638374	5.354489	1.33E-06	1.948001
Within Groups	474.51	963	0.492741			
Total	495.62	971				

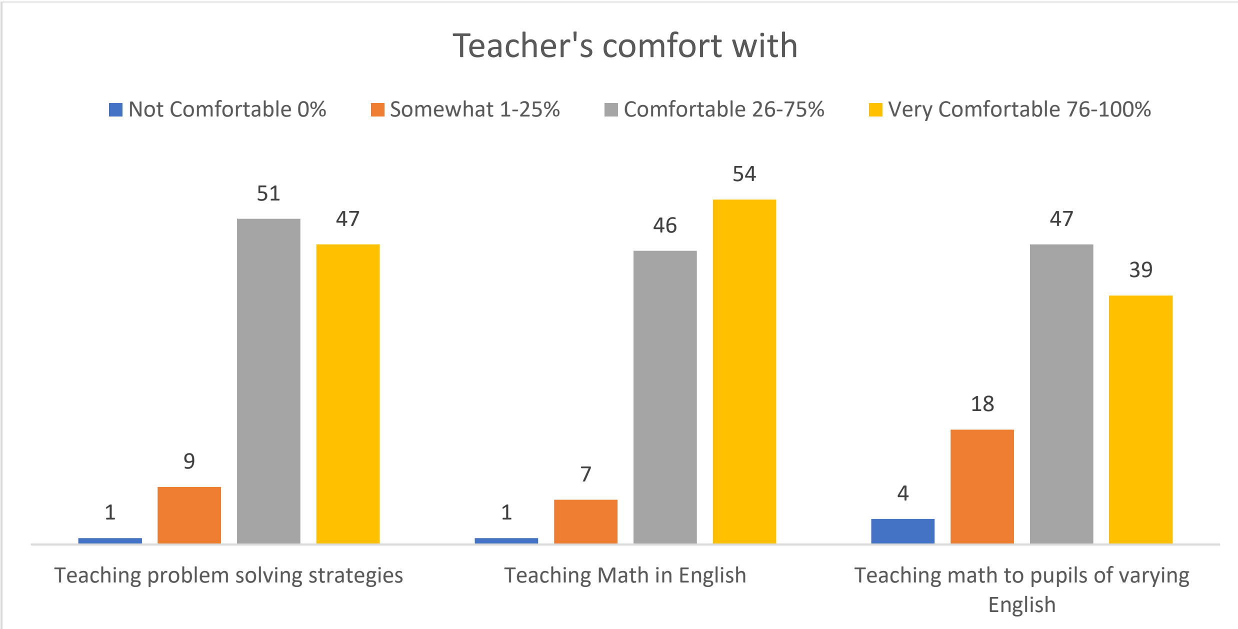
The average of the items' averages was 2.326. Five of the nine (55.6%) had item averages below the overall average. This caused the researcher to investigate further as to what variables could influence the participants response. The table displays the demographics of the participants which gave the lowest scores.

Demographic of participants which self-identified as having less than 25% cmfort with the following aspects of teaching mathematics					
	Teaching mathematics with other subjects (2.23)	**Providing mathematics instruction that meets national mathematics content standards (2.25)**	**Using a variety of assessment strategies (2.31)**	**Teaching a class of pupils with differering mathematical ability (2.17)**	**Teaching mathematics to pupils of differing levels of English proficiency (2.12)**
Lowest score given	(0) 1	1	1	(0) 1	(0) 1
Number of respondents giving the lowest score	(4) 13	16	16	(1) 23	(5) 25
Minimum of Years Teaching	(4) 1	0.5	1	1	(4) 0.5
Maximum Years teaching	(20) 41	32	36	41	(16) 41
STEM major	(2) 3	2	4	4	(0) 3
Education major	(0) 1	3	1	4	(1) 6
College Course - Method of teaching mathematics	(4) 8	9	10	16	(4) 12
College Course - Mathematics content for primary school mathematics	(4) 7	8	10	15	(4) 11

After observing the eight factors regarding the participants which responded with either a 0 or 1 for the five items the characteristics which stood out were:

a. The years of teaching experience was not a factor with respect to their comfort level. The range of teaching experience for those responding with Not Comfortable was 4 to 20, whereas the range for responding having at most 25% comfort was from 0.5 to 41.
b. 50% of the respondents which responded 0 'Not Comfortable' for teaching mathematics with other subjects were a STEM major and 34% respondents stating they were only 25% comfortable with teaching pupils with differing mathematical ability were either STEM or English majors. Those majoring in mathematics or education should have the abilities to do both tasks. To study STEM subjects one should have a strong foundation in mathematics and have the ability to both explain and understand the concepts. And for integration of mathematics with other subjects, more than others, they should have more experience applying their content knowledge, and Education majors should have taken courses related on integration of subjects and teaching pupils with varying ability.
c. When observing the college courses the respondents have taken, it was noticeable that:
    a. All of the participants reporting they were 'Not Comfortable' with teaching mathematics with other subjects had taken both college courses.
    b. For all items except 'Teaching mathematics to pupils if differing levels of English proficiency' over 50% responding with being at most 25% comfortable, have taken college courses in Method of teaching mathematics or mathematics content for primary school mathematics

Three items from this question were further analyzed to determine participants teaching mathematics in English. Drawing from the results of respondents stated that language was their biggest challenge 50% said they are Very Comfortable teaching mathematics in English; however, less are comfortable when the class is made up of non-homogeneous English levels.



It is noticeable yet not overall significant that both relationships for years of teaching and teaching mathematics in English as well as years of teaching and Teaching mathematics to pupils of varying English had weak negative correlations with $r = -0.24771$ and $r = -0.15583$. With further investigation the only participants to respond with 'Not Comfortable' had the following demographics:

Not Comfortable with	Type of School		Highest Education	Major of Study	Teacher College courses completed		Years Teaching	English Proficiency Reading	Speaking	Listening	Writing
Low English	Rural	Private	Bach	Political Sience	Methods of teaching mathematics	Mathematics content courses for primary school math	4	2	2	2	2
Low English	Urban	Public	Bach	Social studies	None	None	36	3	4	4	3
Low English	Urban	Public	Dip	Graphic Design	Methods of teaching mathematics	Mathematics content courses for primary school math	5.0	2	4	2	1
Neither	Urban	Public	Dip	Basic Education	Methods of teaching mathematics	Mathematics content courses for primary school math	4.0	4	4	4	4

75% of the participants that respond not being comfortable with teaching math in English or pupils with varying English have 5 years or less of teaching experience and none of them have a background in mathematics. Therefore, it can be concluded as teachers gain more experience, they become more comfortable teaching pupils of varying English levels.

2. *The agreement with statements which regarding important things for pupils to do. (Q.26)*

There were 114 respondents who answered this question which asked participants to show how much they Agree with a statement using a Likert scale from 0 to 3 implying 'Strongly Disagree' to 'Strongly Agree' respectively. The average response for each item ranges from 2.047 to 2.785 with a question average of 2.398. The number of respondents expressing their level of agreement for each item is displayed in the table as n (%).

26	It is important for pupils to do the following:	Strongly disagree		Disagree		Agree		Strongly agree	
i.	Watch the teacher demonstrate how to solve a problem	1	1%	1	1%	33	31%	79	74%
ii.	Copy notes from the board	1	1%	5	5%	50	31%	58	54%
iii.	Complete computational problems from the textbook or worksheet	0	0%	8	7%	60	31%	46	43%
iv.	Present or demonstrate solutions to a mathematics problem to the class	0	0%	1	1%	56	31%	57	53%
v.	Use concrete resources (ex. bottle caps)	1	1%	10	9%	35	31%	68	64%
vi.	Work individually on mathematics problems or applications	4	4%	19	18%	45	31%	46	43%
vii.	Work in groups on mathematics problems or applications	0	0%	6	6%	55	31%	53	50%
viii.	Do a mathematics activity outside of the classroom (measure the	4	4%	16	15%	51	31%	43	40%
ix.	Use technology in the classroom	2	2%	20	19%	63	31%	29	27%
x.	Maintain and reflect on a mathematics notebook of their own work	0	0%	3	3%	70	31%	41	38%
xi.	Learn vocabulary to help understand math concepts	0	0%	2	2%	66	31%	46	43%
xii	Take a quiz or test	0	0%	1	1%	23	31%	90	84%

To determine if the items were significant within the question, ANOVA was run to determine the p-value. The variance for the second variable is greater than the first therefore the F statistics is valid. The results showed the F – statistic is larger than the F-critical and the p-value $=1.08E-20$ < 0.05 therefore there is significance between the variables.

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Watch the teacher demonstrate how to solve a problem	107	285	2.663551402	0.300829
Copy notes from the board	107	265	2.476635514	0.346147
Complete computational problems from the textbook or worksheet	107	250	2.336448598	0.3763
Present or demonstrate solutions to a mathematics problem to the class	107	267	2.495327103	0.271204
Use concrete resources (ex. bottle caps)	107	265	2.476635514	0.49709
Work individually on mathematics problems or applications	107	233	2.177570093	0.694586
Work in groups on mathematics problems or applications	107	258	2.411214953	0.357609
Do a mathematics activity outside of the classroom (measure the hallway, find the area of the playground)	107	233	2.177570093	0.675719
Use technology in the classroom	107	219	2.046728972	0.516664
Maintain and reflect on a mathematics notebook of their own work	107	249	2.327102804	0.278787
Learn vocabulary to help understand math concepts	107	257	2.401869159	0.280374
Take a quiz or test	107	298	2.785046729	0.189208

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	50.476	11	4.588714245	11.50891	1.08E-20	1.796164
Within Groups	507.16	1272	0.39870981			
Total	557.63	1283				

The average of the items' averages was 2.398. Five of the twelve (42%) had item averages below the overall average. This caused the researcher to investigate further as to which variables could have influenced the participants responses. The table displays the demographics of the participants which gave the lowest scores.

Demographics of the participants that strongly disagreed or disagreed with the statements					
	Complete computational problems from the textbook or worksheet (2.34)	**Work individually on mathematics problems or applications (2.18)**	**Do a mathematics activity outside of the classroom (measure the hallway, find the area of the playground) (2.18)**	**Use technology in the classroom (2.05)**	**Maintain and reflect on a mathematics notebook of their own work (2.33)**
Lowest score given	1	(0) 1	(0) 1	(0) 1	1
Number of respondents giving the lowest score	8	(4) 21	(5) 17	(3) 21	6
Minimum of Years Teaching	0.5	(2) 2	(2) 1	(2) 2	2
Maximum Years teaching	18	(10) 36	(9) 34	(28) 32	17
STEM major	1	(1) 4	(5) 4	(1) 9	1
Education major	2	(0) 6	(0) 4	(1) 7	1
College Course - Method of teaching mathematics	6	(3) 16	(2) 13	(1) 14	4
College Course - Mathematics content for primary school mathematics	5	(3) 14	(1) 13	(0) 14	4

After observing the eight factors regarding the participants which responded with either a 0 or 1 for the five items the characteristics which stood out were:

a. The years of teaching experience was not a factor. The range of teaching experience for those responding with either 'Strongly Disagree' was 2 to 28, whereas the range for responding 'Disagree' was from 0.5 to 36.
b. From the participants which responded with either a 0 or 1 on the Likert scale the 44 and 59% of them made these statements regarding applying mathematics were STEM or Education majors. Mathematics alone can seem unreachable to some students, therefore applying it to the real world makes it more accessible. 75% of the respondents which disagreed with the use of technology are also STEM or Education majors. However, this could be explained by the lack of technology available in their schools.
c. The respondents who disagreed with students working independently on applications or doing an activity outside of class have taken the method of teaching mathematics course (76% and 68%) or mathematics content for primary school mathematics course (68% and 64% respectively.) The response rate disagreeing with this item further supports the previous finding that respondents do not believe creative thinking is important, contradicting literature (Švecová, Rumanová, and Pavlovičová, 2014), which emphasizes the importance of creative thinking in solving mathematics problems.

This question also explored the idea of teacher-centered versus student-centered classrooms. The research evidence indicates that students learn better in student-centered (SC) rather than teacher-centered (TC) environments (Otara, Uworwabayeho, Nzabalirwa and Kayisenga, 2019). The results demonstrated a balance between respondents' beliefs in a teacher-centered class and student-centered class. The results for parts a, and d (a – TC, and d – SC) held the highest percentages for 'Agree' and 'Strongly Agree', apart from pupils taking a test or quiz. The parts which possibly demonstrate a belief in a more student-centered class, d, g, and h resulted in percentages ranging from 82.5% to 99.1%. According to Felder and Prince (2006) the methods of teaching which support student centered learning involve:

- students leading discussions denoted in the survey as item, d, *present or demonstrate solutions to a mathematics problem to the class*
- cooperative learning denoted in the survey as item, g, *Work in groups on mathematics problems or applications*,
- as well as students working on activities both in and out of class, represented by item, h, *Do a mathematics activity outside of the classroom*

The table denotes if the item is categorized as teacher-centered (TC) or student- centered (SC).

Percent (%) of respondents choosing 'Agree' or 'Strongly Agree' (n = 114)

Q. 26 Teachers think it is important for pupils to do the following n = 114												
	Watch teacher	**Copy Notes**	**Complete problems**	**Present or demonstrate solutions**	**Use concrete resources**	**Work individually**	**Work in groups**	**Do activities out of class**	**Use technology in class**	**Make and reflect on math notebook**	**Learn vocab**	**Take quiz or test**
Agree or more	98.246	94.737	92.98246	99.12280702	90.35088	79.824561	94.73684	82.45614	80.701754	97.36842	98.24561	99.12281
	T C	T C	T C	S C			S C	SC				

In addition to what teachers found important it is also important to mention the areas which were not as highly considered. Only 79.8% of the respondents felt it was important for pupils to work individually. While there is a lot of research supporting group work in a mathematics classroom (Zakaria, Chin, & Daud, 2010, and Tarim, 2009) there is also evidence that when students work individually reviewing worked solutions, they demonstrate better understanding (Retnowati, Ayers & Sweller (2017). Working in pairs or groups also supports English learners. The next lowest area teachers viewed as important with only 80.7% agreeing, was the use of technology in the classroom. Many of the teachers do not have access to technology, therefore would not see the value it could add to the pupils' experience in the classroom. With 82.4% in agreement, the participants did not view out of class activities of high importance, however, Švecová, Rumanová, and Pavlovičová (2014) demonstrated activities outside of class fostered creative thinking and deeper understanding of mathematics. The idea of exposing pupils to mathematics outside of class, not being of importance, could suggest teachers are somewhat inclined to be more traditional or teacher centered.

3. *<u>The percent of times a pedagogical skill is used when teaching a complete topic (27)</u>*

There were 113 respondents to this question which asked participants to say how often they use a pedagogical skill when teaching a mathematics topic in class using a Likert scale from 0 to 4 implying 'Never' to 'Always' respectively. The average response for each item ranges from 2.5 to 3.57. The number of respondents stating the items they use in class is displayed in the table as n (%).

27 When teaching a complete topic, how often do you:	Never		At least 25% of the time		At least 50% of the time		At least 75% of the time		Always	
i. Build on skills children already have and/or know	0	0%	0	0%	19	17%	41	36%	53	47%
ii. Use real objects, explanations, representations (picture,	0	0%	1	1%	21	19%	50	44%	41	36%
iii. Use repeated practice to improve pupils' ability to solve	0	0%	5	4%	16	14%	53	47%	39	35%
iv. Have pupils do work with and practice grade-level	0	0%	1	1%	14	12%	55	49%	43	38%
v. Emphasize one solution method to strengthen all pupils'	13	0%	10	9%	21	19%	46	41%	23	20%
vi. Have pupils choose and use appropriate methods when	0	0%	2	2%	13	12%	51	45%	47	42%
vii. Check for understanding throughout the lesson using	0	0%	5	4%	17	15%	33	29%	58	51%
viii. Summarize the mathematics with references to pupil	1	0%	7	6%	19	17%	45	40%	41	36%
ix. Mainly use questions and problems that are from the	2	0%	13	12%	25	22%	40	35%	33	29%
x. Review standards/topics from previous grades	0	0%	1	1%	17	15%	45	40%	50	44%
xi. Ask pupils to explain and justify their work	0	0%	6	5%	15	13%	35	31%	57	50%
xii. Provide feedback to help pupils revise initial work	0	0%	1	1%	7	6%	32	28%	73	65%

To determine if the items were significant within the question, ANOVA was run to determine the p-value. The variance for the second variable is greater than the first therefore the F statistics is valid. The results showed the F – statistic is larger than the F-critical and the p-value =$5.4E-21$ < 0.05 therefore there is significance between the variables.

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Build on previos pupils skills	113	373	3.300885	0.551517
Use real objects	113	357	3.159292	0.563685
Use repeated practice	113	352	3.115044	0.65629
Have pupils do work with and practice	113	366	3.238938	0.487042
Emphasize one solution method	113	282	2.495575	1.537927
Have pupils choose and use approp methods	113	369	3.265487	0.53603
Check for understanding throughout the lesson using deliberate methods	113	370	3.274336	0.772282
Summarize the math with references to pupil work	113	344	3.044248	0.864096
Mainly use questions and problems from text	113	315	2.787611	1.097345
Review standards and topics from previous grade	113	370	3.274336	0.557996
Ask pupils to justify their work	113	369	3.265487	0.78603
Provide feedback	113	403	3.566372	0.426359

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	94.2094	11	8.564495	11.63048	5.40E-21	1.795761
Within Groups	989.699	1344	0.736383			
Total	1083.91	1355				

The overall average of the items 3.15. Four of the twelve (33.3%) items had averages below the overall average. This caused the researcher to investigate further as to what variables could influence the participants response. The table displays the demographics of the participants which gave the lowest scores.

Demographics of participants who stated they perform the following less than 25% of the time when teaching a topic				
	Use repeated practice to improve pupils' ability to solve matheamtics problems (3.12)	**Emphasize one solution method to strengthen all pupils' understanding of the content (2.5)**	**Summarize the mathematics with references to pupil work to reinforce the focus of the lesson (3.04)**	**Mainly use questions and problems that are from the textbook (2.78)**
Lowest score given	1	0	(0) 1	(0) 1
Number of respondents giving the lowest score	5	15	(1) 8	(2) 13
Minimum of Years Teaching	2	2	(20) 1	(20) 0.5
Maximum Years teaching	10	34	(-) 18	(21) 22
STEM major	3	2	(0) 2	(0) 5
Education major	0	3	(0)1	(1) 2
College Course - Method of teaching mathematics	5	15	(1) 5	(2) 13
College Course - Mathematics content for primary school mathematics	3	15	(1) 3	(2) 13

These four had items had lower averages in comparison to the overall average however they only two of them refer to items the participants responded they either 'Never' do or only do 'At least 25%' of the time. These two items were to 'Emphasize one solution method to strengthen all pupils understanding of the content' and 'Mainly use questions and problems that are from the textbook.'

a. The years of teaching ranged from 1 to 34, therefore teaching experience was not a factor.
b. Mathematics is an area where there could be more than one way to solve a problem. pupils should follow logical thinking and others should be able to follow the thought process to reach the solution. To have 33.3% of STEM and education majors answered 'Never'. The researcher would have assumed more would respond with 'Never' to this item.
c. It is noticeable that all (100%) the participants who responded 'Never' to 'Emphasize one solution method to strengthen all pupils understanding of the content' took both college courses, Methods of teaching mathematics and Mathematics content for primary school. This is a concern as this leads to a teacher centered class instead of allowing students to explore.
d. All of the respondents (100%) responding with either 'Never' or 'At least 25% of the time' to mainly use question and problems that are from the textbook took both college courses. The teachers should be able to create problems which expand on what the students have practiced from the textbook. Exposing pupils to unfamiliar problems allows for understanding of similar topics in various contexts, therefore strengthening their learning.

As teachers would have several class periods to complete topic, there would be enough time for all twelve skills to be utilized at least once. However, most of the topics were only completed 'At least 50% of the time', when finding the percent of topics which are completed 'At least 75% of the time', the percent of positive response decreased significantly.

Percent (%) of respondents choosing ‘At least 75% or more’ or ‘At least 50% or more’ (n=113)

Q27. When teaching a complete topic, how often do teachers n = 113												
	Build on previos pupils skills **	Use real objects	Use repeated practice	Have pupils do work with and practice	Emphasize one solution method	Have pupils choose and use approp methods	Check for understanding throughout the lesson using deliberate methods	Summarize the math with references to pupil work**	Mainly use questions and problems from text	Review standards and topics from previous grade**	Ask pupils to justify their work	Provide feedback
At least 75% or more	83.18584	80.53097	81.41593	86.72566	61.06195	86.72566	80.53097	76.10619	64.60177	84.0708	81.41593	92.92035
At least 50% or more	100	99.11504	95.57522	99.11504	79.64602	98.23009	95.57522	92.92035	86.72566	99.11504	94.69027	99.11504

Felder and Prince (2006) state “students learn by fitting new information into existing cognitive structures and are unlikely to learn if the information has few apparent connections to what they already know and believe (p. 2).” The results demonstrated that the 93% or more of the respondents used this method of teaching ‘At least 50% of the time’. The three items demonstrating making previous connections have '**’ in the table.

What are their pedagogical beliefs regarding teaching mathematics to English learners?

Section two of the survey was used to investigate the participants basic mathematical knowledge, problem solving skills and their ability to interpret student work, however, the analysis focused a little more on participant response when asked about the students’ misunderstanding.

Scenario One

A person’s beliefs can be grounded in the strength of both their content and pedagogical knowledge (Clark, et.al, 2014). Participants were given two basic mathematics computations with fractions, adding common denominators, and subtracting with unlike denominators. The content is taught in primary grades three and four respectively. Respondents were to give the correct answer for each question as well as to explain the pupils’ misunderstanding.

In the first part of each question, participants needed to give the correct answer. The results for both the fraction problems had positive results with 98% and 94% respectively.

Adding Fractions with common denominators n = 110		
	n	**%**
Gave the correct answer	108	98.18182

Subtraction of fractions with uncommon denominators n = 116		
	n	**%**
Gave the correct answer	100	94.33962

Gave Incorrect answer	2	1.818182		**Gave Incorrect answer**	6	5.660377

The second part of each question asked for the participants to explain the pupil's misunderstanding of the problem, which led them to the incorrect answer. Participant responses were considered incorrect if they did not address the most important concept missed by the student.

Do not add denominators when adding fractions		
	n	**%**
Gave the correct answer	80	77.6699
Gave Incorrect answer	23	22.3301

Need to get a common denominator before subtracting		
	n	**%**
Gave the correct answer	70	72.91667
Gave Incorrect answer	26	27.08333

It is concerning that the participants had such a high rate of success when solving the computation, however they were unable to explain what the pupil did incorrectly. As a teacher explaining both how to solve a problem and having the ability to interpret and rectify student misconceptions and misunderstanding is vital. Below are examples of incorrect teacher responses;

1. **Addition of fractions with a common denominator – the incorrect responses either did not address the students mistake**
   The pupil had problem by not changing the answer into mixed fraction
   The pupil just added the numerators and wrote it down
   Added the numerators and the denominators without finding the common multiples of the denominators
   Misunderstands LCM
   Misunderstands the concepts of addition

2. **Subtraction of fractions with an uncommon denominator**
   Misunderstood by subtracting the denominators
   Subtracted the two denominators and the two numerators
   Cannot break fractions down to the simplest form
   Had problem with cancelation
   Does not know how to subtract fraction

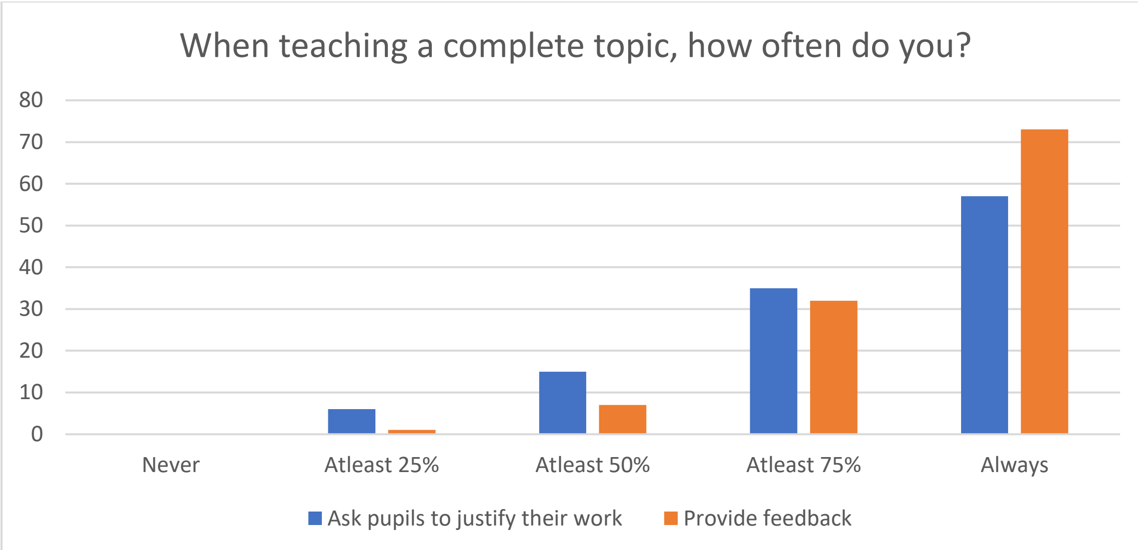
Demographic of the participants unable to explain the pupil's misunderstanding			
Addition of fractions with a common denominator	n	**Subtraction of fractions with an uncommon denominator**	**n**
Incorrect responses	23	Incorrect responses	26
Missed both calculation and explanation	1	Missed both calculation and explanation	3
Minimum Years of Teaching	0.5	Minimum Years of Teaching	0.5
Maximum Years of teaching	36	Maximum Years of teaching	22
STEM major	6	STEM major	7
Education Major	2	Education Major	3
College Course – Method of teaching mathematics	13	College Course – Method of teaching mathematics	18
College Course – Mathematics content for primary school mathematics	13	College Course – Mathematics content for primary school mathematics	15

12 of the respondents missed both explanations.

For the 'Addition of Fraction' only one of the twenty – three respondents missed both the calculation and the explanation. The other twenty-two missed only the explanation portion of the question. Therefore, they know how to solve the problem however they are unable to explain their reasoning or understand why a student has made an error in their work. In section one participants were asked to tell how often they asked students to explain their reasoning as well as how often they provided feedback to help students.

The response was overwhelmingly positive, demonstrating that over 85% of the teachers do this when teaching.

n=113	Ask pupils to justify their work	Provide feedback
Never	0	0
At least 25%	6	1
At least 50%	15	7
At least 75%	35	32
Always	57	73
Average	3.265487	3.566372
Std. Dev	0.886584	0.652962



Looking at the cumulative percent of teachers, who claim to do both always and at least 75% of the time or more find that 93% provide feedback to students.

n=113	**Ask pupils to justify their work**	**Provide feedback**
Always	50.44248%	64.60177%
At least 75% or more	81.41593%	92.92035%

If a participant provides feedback 93% of the time when teaching, however, does not give accurate feedback correcting a student's work, the researcher concludes that the feedback when teaching will not lead to assisting the pupils in their learning or understanding of the mathematics topic. The feedback the respondent is referring to is only evaluative, i.e. correct or incorrect, but not explaining or questioning where the student has a misunderstanding.

Scenario Two

This section asked participants to correct students work on word problems.

The results of each word problem are separated by problem. The word problems had more incorrect answers then the basic computations, and the explanations had more incorrect responses as well. With each problem in this section the accuracy of the responses and the actual responses were less.

The responses from the first word problem, 'The Farmer's Total' were reviewed for the calculation and the interpretation of the pupil's misunderstanding. Each part had some blanks (Null) however, some had answered the calculation but left the interpretation blank or gave an interpretation and left the calculation blank. Therefore all 121 responses are in the table. In addition to the correct solution, the researchers were looking to see if the respondents would see and mention the pupil's misunderstanding of the vocabulary word 'total' in the explanation.

	Farmer's 'Total'					
	Correct Responses		Incorrect Responses		Null	
	n	%	n	%	n	%
Calculation of problem	67	55%	23	19%	31	26%
Pupil's Misunderstanding	37	31%	48	40%	36	30%

55% of the respondents were able to correctly calculate the answer for the word problem however only 31% were able to give the correct interpretation of the pupil's misunderstanding. The respondents which answered the pupil's misunderstanding correctly used proper vocabulary with unit price, a concept explored in primary school.

Correct and incorrect examples of the responses to the Pupil's Misunderstanding (as written by participant).

Examples of Pupil's Misunderstanding Responses	
Correct Responses	Incorrect Responses
Pupil should have multiplied 50(1.2), 60cabbages by 0.8 and 2 basket of tomatoes by 13.5	*The child mixed the decimal point in the cedis*
Pupil should have multiplied each item by their unit price and add them after that	*Pupil doesn't understand the concept of multiplication*
Misunderstands how to multtiply a quantity by it unit price	*Did not calculate the number of items well*
	Needs understanding of the vocabulary of money
	The pupil should have multiply the total of the items and add

Researchers were interested in the demographics of the participants that responded incorrectly to the pupil's misunderstanding. The years of teaching experience was not significant as the range was from 0.5 to 36 years. The other noticeable findings were that 27% of the STEM majors could not explain the pupil's misunderstanding. It leads the researcher to conclude they may know the content and not pedagogy or they do not know how to explain.

Demographics of participants that responded incorrectly to pupil's misunderstanding n = 48		
	n	%
STEM major	13	27%
Education major	8	17%
College Course - Method of teaching mathematics	31	65%
College Course - Mathematics content for primary school mathematics	28	58%
Responded 'Very Comfortable' to Teaching Problem Solving Strategies' (Q16e)	16	33%

The high percentage of participants that took the college courses and yet were still unable to explain the students misunderstanding is over 50%, but the 65% for the methods course is the most concerning. Participants which have taken a method of teaching mathematics should be able to review and give feedback on students work. Furthermore, 33% of the participants with an incorrect response stated they were 'Very Comfortable' teaching problem solving strategies. This leads the researcher to question what strategies they are using to teach problem solving if the understanding is not evident.

The responses from the second word problem, 'Akua's Money' were reviewed for the calculation and the interpretation of the pupil's misunderstanding. Each part had some blanks (Null) however, some had answered the calculation but left the interpretation blank or gave an interpretation and left the calculation blank. Therefore all 121 responses are in the table.

	Akua's Money Left					
	Correct Responses		Incorrect Responses		Null	
	n	%	n	%	n	%
Calculation of problem	61	50%	28	23%	32	26%
Pupil's Misunderstanding	44	36%	37	31%	40	33%

50% of the participants were able to answer this question correctly, however only 36% of them were able to give the correct response to pupil's misunderstanding. For this word problem the correct response was given by the teachers as, "Mistook the change as the principal" or "Mistook the change as the actual money". Both demonstrate proper usage of mathematics vocabulary. Only one participant mentioned the polysemous word 'left', which is the *change* being discussed. When teaching or speaking with students it would be beneficial to highlight this vocabulary word in the lesson or when going over problems.

Correct and incorrect examples of the responses to the Pupil's Misunderstanding (as written by participant).

Examples of Pupil's Misunderstanding Responses	
Correct Responses	**Incorrect Responses**
Mistook the change for the actual money	*The pupil really didnt understands the whole concept very well*
Pupil mistook the left over money as the actual money	*Find it difficult to understand word problem*
The pupil mistook the change for the money Akua had beforegoing shopping and subtracting what she spent from it	*Lack the concept of logical thinking*
	Misunderstands the concept of addition and subtraction

Researchers were interested in the demographics of the participants that responded incorrectly to the pupil's misunderstanding. The years of teaching experience was not significant as the range was from 0.5 to 41 years. The other noticeable findings were that 32% of the STEM majors could not explain the pupil's misunderstanding. It leads the researcher to conclude they may know the content and not pedagogy or they do not know how to explain.

Demographics of participants that responded incorrectly to pupil's misunderstanding n = 37		
	n	**%**
STEM major	12	32%
Education major	8	22%
College Course - Method of teaching mathematics	21	57%
College Course - Mathematics content for primary school mathematics	21	57%
Responded 'Very Comfortable' to Teaching Problem Solving Strategies' (Q16e)	19	51%

57% of the participants took both the of the college courses, method of teaching mathematics and mathematics content for primary school mathematics. Participants which have taken a method of teaching mathematics should be able to review and give feedback on students work. Furthermore, 51% of the participants with an incorrect response stated they were 'Very Comfortable' teaching problem solving strategies. This leads the researcher to question what strategies they are using to teach problem solving if the understanding is not evident.

Four respondents were able to accurately calculate the response to the last word problem, “Minimum Number of Teams.” Each part had some blanks (Null) however, some had answered the calculation but left the interpretation blank or gave an interpretation and left the calculation blank. Therefore all 121 responses are in the table.

	Minimum Number of Teams					
	Correct Responses		Incorrect Responses		Null	
	n	%	n	%	n	%
Calculation of problem	4	3%	37	31%	80	66%
Pupil's Misunderstanding	8	7%	32	26%	77	64%

Only 3% of the participants were able to answer this question correctly, and 7% were able to give the correct response to pupil’s misunderstanding. For this word problem the correct response was given by the teachers as, “Did not understand maximum and minimum” which demonstrates the proper usage of mathematics vocabulary.

Correct and incorrect examples of the responses to the Pupil’s Misunderstanding (as written by participant).

Examples of Pupil's Misunderstanding Responses

Correct Responses	Incorrect Responses
Pupil misunderstands minimum for maximum	*Lacks basic division skills*
Misunderstands difference between minimum and maximum	*Pupil needs to understand the vocabulary of money* *The child had to divide 42 by 11 and it will give him 3 remainder 9 instead of 3 remainder 8*
	The minimum is rather 1

The responses from the four participants which had the calculation correct had have the misunderstanding of the pupil about the remainder and misunderstanding about division. These responses are not exactly wrong; however, they are not what leads to the misunderstanding of the problem.

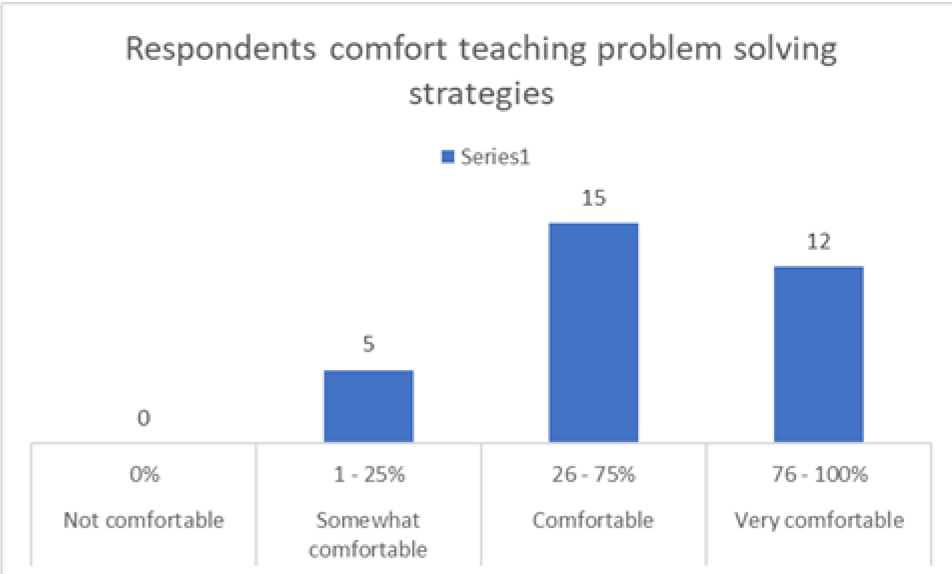
Responses to the Pupil’s Misunderstanding for the four correct calculations (as written by participant).

Calculation Correct - Pupil's Misunderstanding response n = 4
Every number after a point is rouded up to 1
Misunderstands how to convert decimal to whole number
Misunderatnds division
Misunderstands decimal point

Researchers were interested in the demographics of the participants that responded incorrectly to the pupil's misunderstanding. The years of teaching experience was not significant as the range was from 0.5 to 36 years. All of the respondents that missed the pupil's misunderstanding have taken both college courses, method of teaching mathematics and mathematics content for primary school teaching.

Demographics of participants that responded incorrectly to pupil's misunderstanding n = 32		
	n	**%**
STEM major	5	16%
Education major	5	16%
College Course - Method of teaching mathematics	32	100%
College Course - Mathematics content for primary school mathematics	32	100%
Responded 'Very Comfortable' to Teaching Problem Solving Strategies' (Q16e)	12	38%

38 % of those with the incorrect response for the pupil's misunderstanding stated they were 'Very Comfortable' teaching problem solving strategies. However, there were not able determine that the misunderstanding of the pupils was there understanding of maximum and minimum, common mathematical terms.

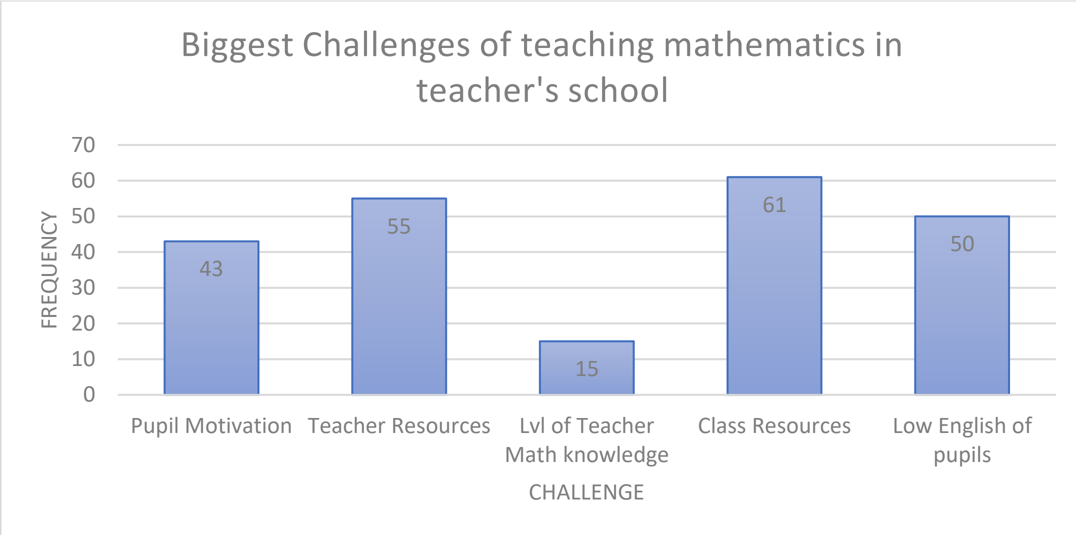


The researchers can conclude that the teachers, responding incorrectly did not understand understanding the terminology of maximum and minimum. The numerical responses gave the impression the respondents only divided and did not think about the remaining students. This is an important skill when problem solving. When solving this or any word problem it is important to ensure that your result answers the question being asked and that it is reasonable (Poyla, 1945). Secondly, the respondents lack of awareness regarding the importance of mathematics vocabulary in solving word problems.

None of the participants received accurate answers for all three-word problems. However, they reported an average of 2.3 (out of 3) regarding their comfort with teaching mathematical problem-solving strategies. For them to report this level of comfort one would assume they would be able to demonstrate their problem-solving ability. Therefore, the teachers comfort their problem-solving strategies is not synonymous with the ability to solve them. When solving word problems there are considerations outside of only mathematical content knowledge. For the population, we are studying and their students, the participants should have a strong base in mathematics, the English language and teaching strategies for ELL learners.

If the participants already believe they have the skills needed, but actually do not how will they help students. The problems that were solved in the survey are all contextual to Ghana and targeted to primary grades four and five. Therefore, since all the teachers are teaching this level, and have years of experience teaching these levels, they should have been able to both successfully answer the questions and explain the students misunderstanding.

In a survey question from part one, participants reported teachers' level of mathematics was not a challenge. Their responses to the word problems contradicts their initial beliefs.

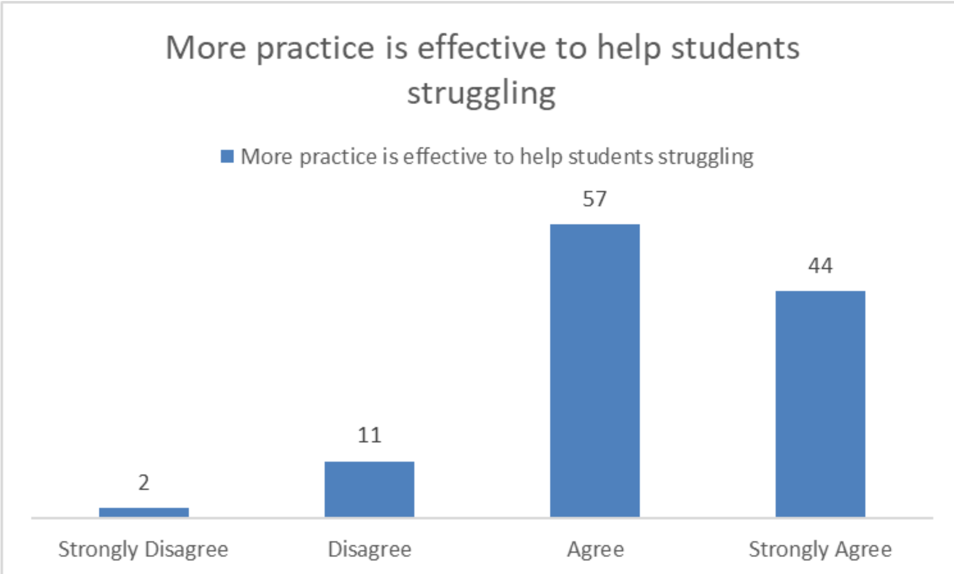


The last free response question asked for the participants to give what next steps they would do with the students in their class after completing money problems. Fifty-five (45%) respondents left the question blank. Those who did respond suggested that next steps should be more work on word problems and story problems as being needed. There was one which discussed revisiting mathematics vocabulary, but the others discussed giving students more practice.

In conclusion this section provided very strong evidence that participants are not focused on the language of the problems. This is demonstrated in the fact only 2 participants (1.7%) mentioned reviewing vocabulary words as next steps. Some of the responses from the participants regarding the next steps at the conclusion of the section were:

- *Encourage to work hard*
- *Solve more questions*
- *Give more practical examples*
- *A lot of practice can be done on word problem*
- *Solve more questions*
- *Pupil must be given alot of problems to solve*
- *More studies on word problems*
- *More calculation should be given to the pupil*

A common theme is to do more practice which may not be helpful if students do not understand the concept or have proper strategies to solve word problems. This correlates to responses from a closed question in section one of the survey.



Discussion

The free response questions of the survey demonstrated the most impactful information regarding the participants. To be effective mathematics teachers to ELL students, the teacher needs a solid understanding of mathematics vocabulary (Chard, n.d.) and only 40% of the respondents 'strongly agreed' that students should learn vocabulary. The free response question posed to the participants, "In what ways do you explain new mathematics vocabulary?", 31.25% of the answered "Explain". The results of this question led the researchers suggest rewording the question for future use, such, as, "In what ways do you explain new mathematics vocabulary?" to avoid these types of ambiguous responses.

When asking participants to give both the English definition as well as the mathematics definitions for word which they will teach in primary the results were not at the level expected. The results of the words 'even' and 'product' were:

Q.36 Polysemous Word 'Even' n=107		
	n	**%**
Correct English	73	68.2243%
Correct Math	84	78.50467%

Q.36 Polysemous Word 'Product' n = 111		
	n	**%**
Correct English	91	81.98198%
Correct Math	49	44.14414%

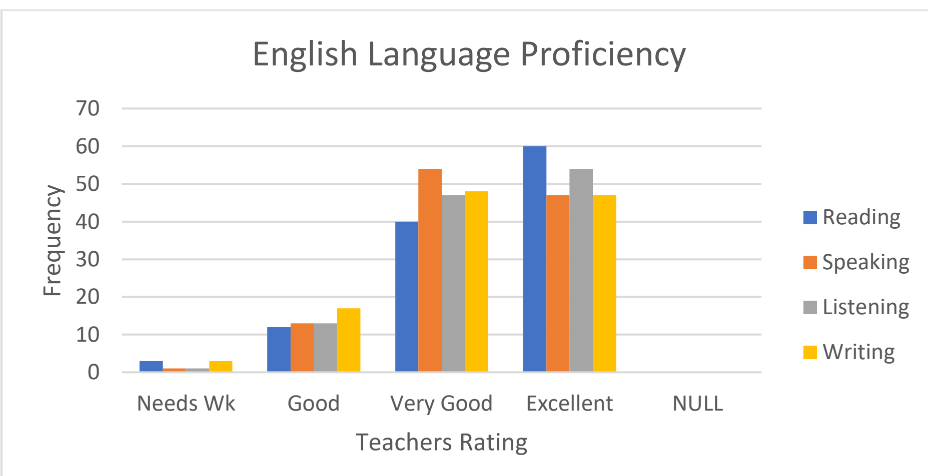
The respondents (51%) stated that language was the main challenge in their classroom, however only 19.6% of the respondents would 'Pre-teach mathematics vocabulary' a strategy recognized as effective (Robertson,2019 and Chard, n.d.).

It was also determined from the problem-solving portion of the survey:

1. Respondents were successful in basic computations for the grade level they teach with 98% and 94% responding correctly.
2. Respondents were less successful, 77.7% and 73%, when they needed to explain the misunderstanding shown by the pupil which could be attributed to
    a. Teachers lack language skills
    b. Teachers lack pedagogical knowledge when teaching fractions
3. The respondents were not as confident when solving the word problems with 74.4%, 69%, and 9.8% responding correctly.
4. The explanations given as feedback for the pupils possibly also demonstrates the lack of importance language in word problems is to the teachers. There accurate responses respectively were 54%, 54% and 18%.

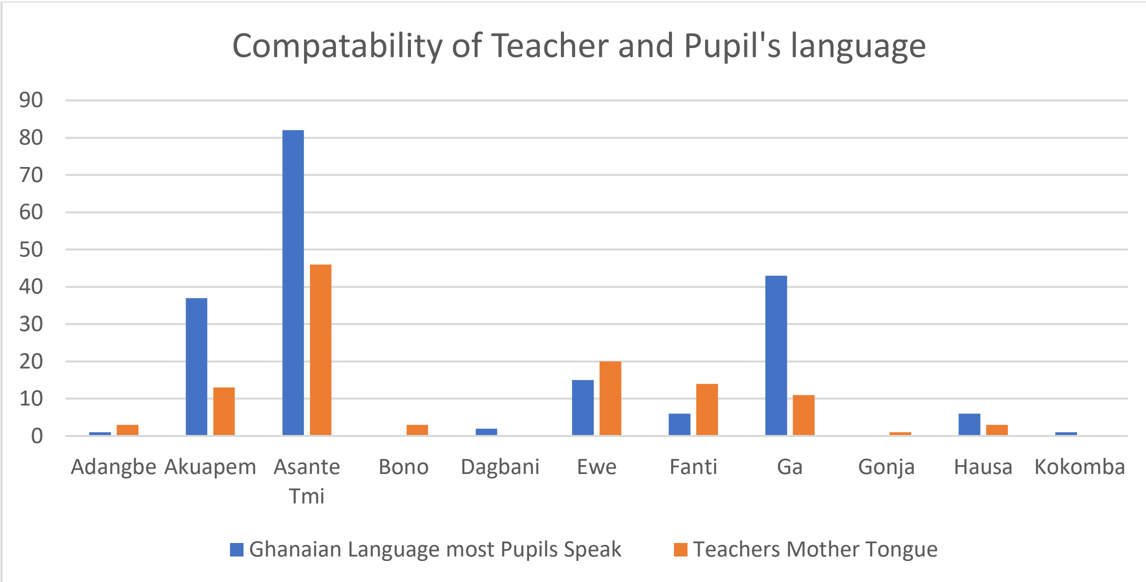
An additional aspect of teaching mathematics in English would be the English proficiency of the participants. Solving word problems depends on strong reading and mathematical skills and explaining the word problems to the students would depend on the participants having strong pedagogical skills.

The participants responded they had high English proficiency. The table gives the participants levels of English proficiency.

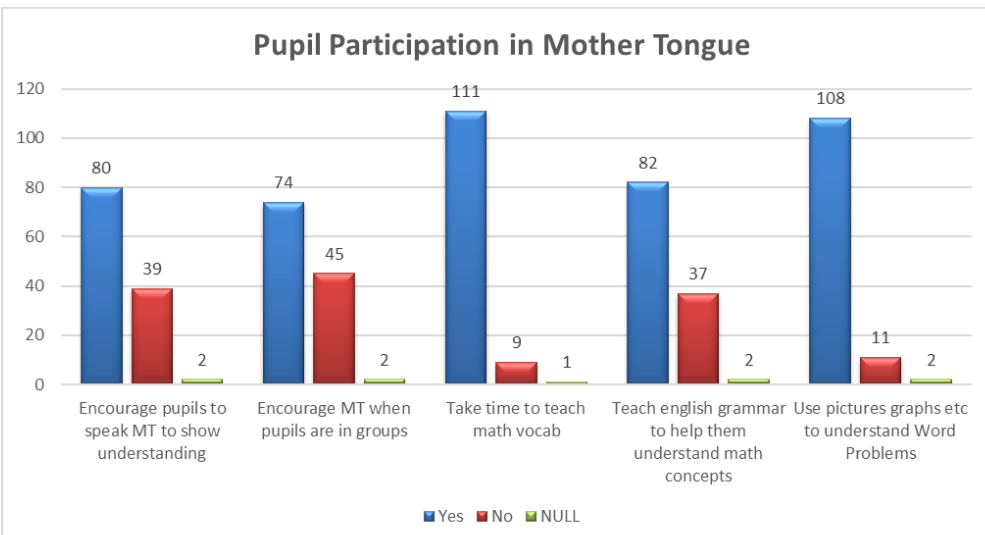


Within the ELL classroom it is helpful to be able to communicate in the same language as the students in the classroom.

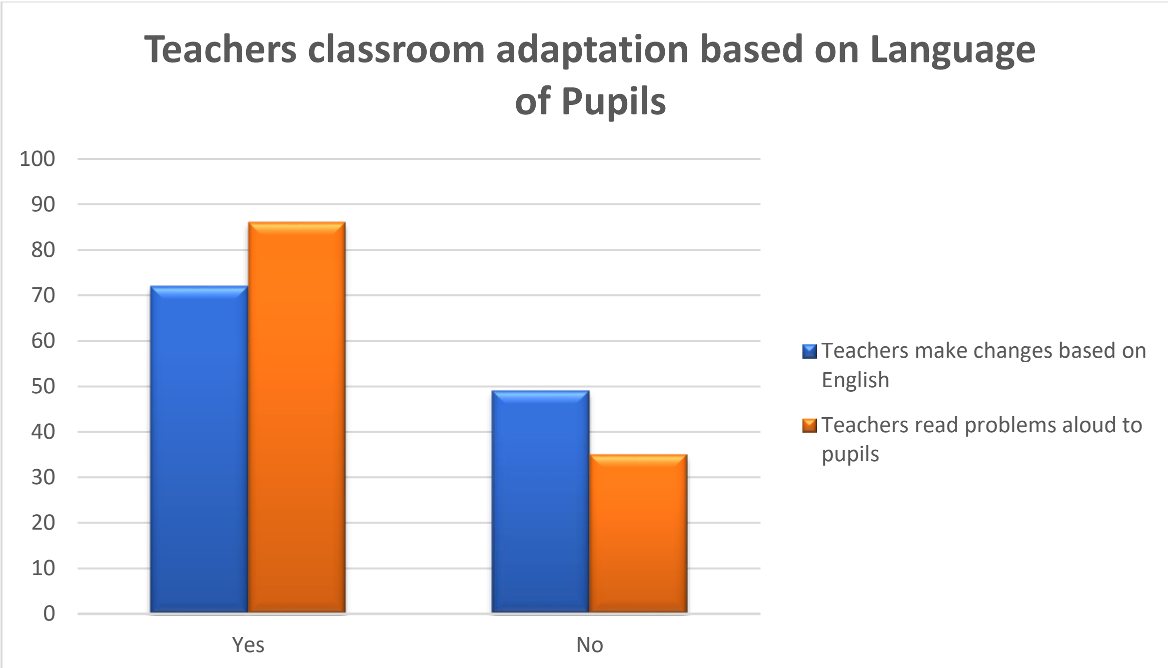
The graph displays the compatibility of the languages spoken in the class of the Teacher and Pupil's.



In addition to the majority of both teachers and pupils speaking Asante Twi, teachers encourage pupils to work in their mother tongue to assist in the mathematics understanding.



Participants also report adapting their assessments based on language of the pupils.



There was an additional variable which should a significant effect on teaching mathematics in English.

Years of Experience effect on	P - value	Significant or Not Significant
Teaching a class with differing mathematical ability	0.04207829	Significant
Teaching mathematics in English	0.01140884	Significant
Teaching mathematics to pupils of differing levels of English proficiency	0.142895287	Not Significant

Participants with more teaching experience expressed higher positive results in two areas, teaching a class with differing mathematical ability and teaching mathematics in English.

Stipek, Givvin, Salmon, and MacGyvers (2001) researched how teachers beliefs related to the instruction on mathematics. They also discuss self-confidence and its impact on teachers' enjoyment of mathematics and therefore have a higher chance of instilling positive beliefs of mathematics in their students. Based on this the researcher investigated if there was a correlation between the participants comfort level and the college courses they have taken.

The correlation between the college courses the participants may have taken and their comfort level with the four variables demonstrated a weak to moderate relationship. There was one relationship that demonstrated a negative correlation and that was between the participants which took a *college course in methods of teaching mathematics* and their comfort with *teaching problem solving strategies*.

The positive relationships ranged from 0.01908 to 0.661077.

The two highest relationships were:

Relationship	Correlation
Methods of teaching mathematics **and** Comfort with teaching problem solving strategies	0.661077
Comfort with teaching the National Curriculum and Comfort with teaching problem solving strategies.	0.610847

Neither of the two are considered strong however it appears that if a goal is to have more teachers have success when teaching problem solving strategies, they should take a college course in Methods of Teaching Mathematics. In addition, college courses were also seen to influence what teachers do when they are teaching, therefore the courses need to focus on determining student misconceptions between what they believe and what they do.

Using Excel, the researcher ran an ANOVA single factor test to see if any of the variables demonstrated significance. The results showed the 'F' value was greater than the 'F critical' value therefore there is significance between the college courses and what the teachers do when teaching a complete topic in class. To determine which of the variables were significant a Regression Analysis was run to identify the variable. The results based of which the college courses had significant effect on the actions of the teacher are represented in the table.

College course taken	**Teachers action when completing a topic**	**p-value < 0.05 Demonstrating significance**
Methods of teaching mathematics	Build on previous pupils' skills	0.005712
	Use real objects, explanations, representations to help pupils understand mathematics problems	0.034452
	Have pupils choose and use appropriate methods when solving a problem	0.006603
	Check for understanding throughout the lesson using informal, but deliberate methods	0.00102

Mathematics content courses for primary school mathematics	Check for understanding throughout the lesson using informal, but deliberate methods	0.038939
Mathematics content courses for secondary school mathematics	Emphasize one solution method to strengthen all pupils' understanding of the content	0.009102
	Ask pupils to explain and justify their work	0.027533

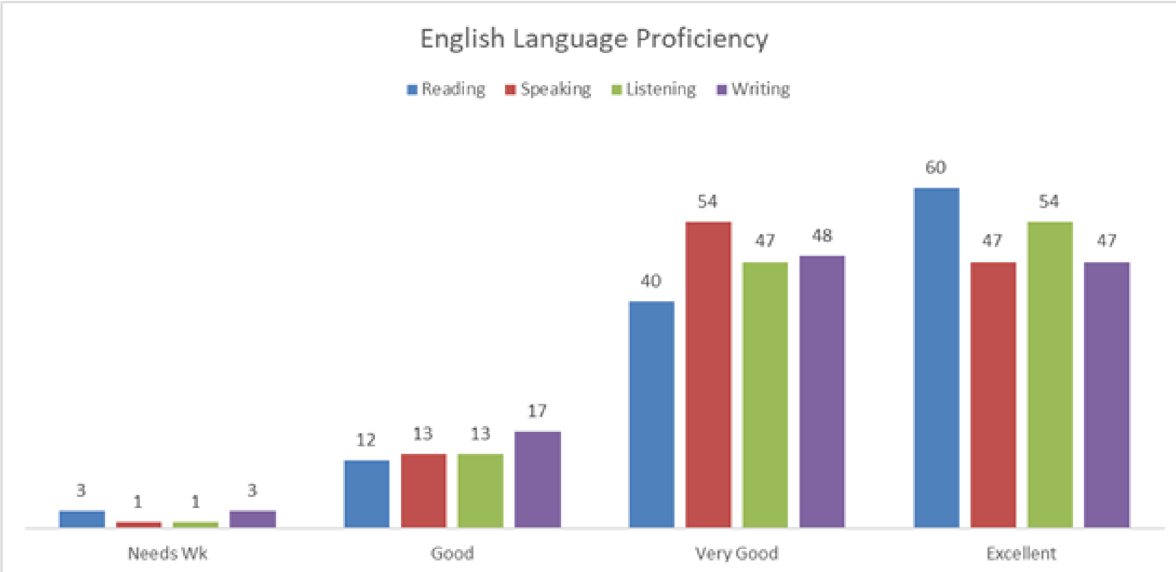
Further interaction with the respondents, such as classroom observations or individual interviews would provide more details as to how they teach the ELL students in their class.

Conclusion

Primary school mathematics is a foundation for pupils' academic career, if their foundation is weak, they may not be able to be successful in subsequent grades. The purpose of this study was two-fold. First it developed and validated an instrument to assess upper primary teacher pedagogical knowledge and beliefs about teaching English learners. Researchers performed a pre-test and pilot test as part of the validation process. The survey was modified after cognitive interviews with teachers. The survey still had some limitations, for example, more clarifications were needed regarding the use of terms like explaining. The survey should not include questions requesting participants to rank items. Additionally, a question should have been asked regarding how the participants feel about mathematics themselves. Literature has shown that primary teachers are not as confident teaching mathematics because many do not like mathematics.

Second, the researchers analyzed the teacher responses to the survey during the pilot. The participants demonstrated a fairly positive attitude regarding the nature of mathematics; however, they were not enthusiastic about pupils doing mathematics activities outside of the classroom. As the literature states creative thinking can assist in school mathematics classes. It allows the students to take some control over their learning and for ELLs it is an opportunity to explore and work with their peers.

An added challenge for pupil's is learning mathematics in English, a second or even third language for them. So, they are learning two new subjects simultaneously, where one depends on the other. Teachers in the classroom need more than just the ability to speak English. They need several important pedagogical skills to be able to teach English effectively. The percentage of participants self-reported their English proficiency at Excellent were 52%, 41%, 47% and 41% for reading, speaking, listening, and writing respectively.



Even with the high level of English proficiency, they were not able to identify when English may be an issue for the students.

The teachers need the two college courses many have taken; however, they also need a course in in teaching ELL. Participants of the study have a range of teaching experience and it was seen that, they become more comfortable as they spend more time in the classroom. However, this does not lessen the newer teachers' anxiety in teaching mathematics in English or having pupils of varying English levels.

It is concerning that the participants had such a high rate of success when solving the computation problems in section two, however they were unable to explain the pupils' misunderstanding. It is important teachers understand the importance of using the appropriate vocabulary and highlighting nuances when teaching mathematics to ELLs. As a teacher explaining both how to solve a problem and having the ability to interpret and rectify student misconceptions and misunderstanding is vital. The teachers in this study, clearly had a grasp of basic mathematics, but seemed to have challenges interpreting student work. Furthermore, they also seemed to understand the need to be student-centered but did frequently choose strategies and statements that were more teacher-centered than student-centered. In light of these findings, it is clear that more studies, particularly qualitative ones, need to be conducted in low- and middle-income countries to explore teacher challenges, and pedagogical knowledge of teaching mathematics to English learners. Further research should be conducted in the areas of teacher preparation and the need to prepare teachers to teach English learners, and student perspectives and challenges with learning mathematics in English.

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