Influence of Pupils' Reasoning Ability and Gender on their Multiplicative Thinking

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Abstract
This study investigated influence of pupil’s reasoning ability and gender on their multiplicative thinking. The population of the study consisted of 108,741 pupils from 537 basic schools. A total of two thousand two hundred and forty students were selected using stratified random sampling technique. Ex-post facto design was used for the study. Two instruments were used for data collection. These were the Multiplicative Thinking Performance Test (MTPT) and Reasoning Ability Test (RAT). The instruments were constructed, validated by two experts in measurement and evaluation and two mathematics education experts and used for the study. Mean, standard deviation, One-way Analysis of Variance (ANOVA) and the Scheffe’s Post Hoc Comparison were used for data analysis. The results among others showed significant influence of pupils’ reasoning ability and age on their multiplicative thinking. It was found among others that pupils reasoning ability and age are significant determinants of multiplicative thinking. Conclusion from findings led to the recommendations that teachers should stress the process of iteration schemes (sees a set, that is, number as a unit and second, the distribution of this quantity across another) which would assist pupils to develop high reasoning ability and make them multiplicative thinkers.

Keywords: Pupils' Reasoning Ability, Gender and Multiplicative Thinking

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Multiplicative thinking refers to the ability of working easily with multiplication concepts, strategies and representations as they appear in ranges of concepts (Siemon, 2005). Siemon opined that it has to do with the ability to easily and effectively work with an extended range of figures and solve problems involving multiplication or division, in addition to other mathematical concepts involving multiplication and division. Siemon further stated that it involves the effective communication of the process in different ways. The use of additive thinking by children for solving multiplication problems has been well documented (Lamon, 1994). Lamon (1994) stated that the concept of multiplication is beyond repeated addition, and it said to be complicated. Starting the teaching of multiplication with repeated addition may be right but interpreting it as the same with multiplication is wrong. This is because it does not provide pupils with the essential structures of multiplication.

Multiplicative thinking requires re-conceptualization of the knowledge of unit (Hiebert & Behr, 1988). Multiplication and addition have different units in terms of conceptualisation and they involve hidden assumptions. The multiplication hidden assumption has to do with the unit one and more than one at the same time while that of addition has to do with only one unit (Chandler & Kamii, 2009). For instance, there are three lions, and two goats are used to feed each for a day. If, it is then asked, how many goats will be required to feed the three lions for a day? The child with an additive thinking would state: (00) goats + (00) goats + (00) goats = 6 goats that is, 2 goats plus 2 goats plus 2 goats to give 6 goats. This thinking has to do with only one unit; the goat. The child with the multiplicative thinking would state thus:

\[
\begin{array}{ccc}
  \text{(00) goats} & \rightarrow & \text{(00) goats} & \rightarrow & \text{(00) goats} \\
  \text{Lion} & \rightarrow & \text{Lion} & \rightarrow & \text{Lion}
\end{array}
\]

That is, 2 goats to one lion. This implies 2 goats multiplied by 3 which gives 6 goats. This thinking involves one unit as well as more than one simultaneous; the goat, the goat and the lion. Multiplicative thinking involves the relationship between the goat and the lion which is not in additive thinking. The re-conceptualization of the knowledge of unit in multiplication has resulted to the poor achievement of pupils in mathematics.

Multiplication has posed a lot of problems to children at upper levels of primary school (Ell, Irwin & McNaughton, 2004; Siemon, 2005). Seah (2004) in his research of the development of multiplicative thinking which resulted from the pupils’ knowledge of multiplication found that many pupils understand little of multiplication and such knowledge is only in regard to the procedure rather than real understanding. Clark and Kamii (1996) found that pupils have trouble in gaining the knowledge of multiplication meaningfully throughout elementary school. Children having trouble in gaining the knowledge of multiplication meaningfully is not necessarily because of its mathematical content, but due to a lot of other factors (Seimon, 2005). Seimon further stated that these factors could be teacher related, student related, school or home environment related. It is important, therefore, to examine these variables which are associated with performance of pupils in multiplication.

The pupils-related factors being very essential could be from the pupils reasoning ability. Pupils' reasoning ability is considered as an essential factor in the evaluation of their performance in learning and a sign of their potential future performance (Telia, Telia, Adika & Toyobo, 2008). According to Telia, Telia, Adisa and Toyobo (2008), it refers to the
nonverbal, deductive, inductive or analytical thinking of pupils. Aiyedun (2007) citing Butter and Wren (1960) stated that reasoning ability is very significant for all pupils to succeed. This is because pupils are not only required to remember mathematical principles they have been taught but they need to apply them to mathematical problems that they have not previously solved. This means pupils should be able to analyse and find the relationship between various components of a given mathematical problem and logically synthesize the problem to get the correct answer. This makes pupils rely on their reasoning ability than the reproduction of class notes. Boujaoude, Salloum and Khalick (2004) stated that grouping pupils in terms of ability highlights a general problem of educational equality among economically diverse pupils' populations. Since reasoning ability plays a vital role in school mathematics, pupils who do not attain to a given level of reasoning may perform poorly (Aiyedun, 2007). Hence, Aiyedun (2007) further opined that grouping pupils into high, average and low abilities become necessary in order to find whether the poor performance of pupils can be related to their reasoning ability in previous mathematics classes. Reasoning ability develops qualitatively in different stages according to the age of the child due to experiences gained (Woolfolk, 2006). This implies that children at older ages would have a relative developed reasoning ability when compared to their young ones.

The implementation of the free universal basic education in Bayelsa State has generated sudden influx of relatively old first graders into schools. This may result to pupils of diverse ages attending the same grade level. A large variance of students’ age within the classroom may pose challenges to teachers in providing instruction appropriate to students with different academic readiness (Wang, 2001). Wang (2001) further stated that these classrooms may also be prone to discipline and behavioural problems as students with different mental maturities interact with each other. As a result, large classroom age variance may impede learning. As cognitive skills are linked to economic growth, earnings and productivity, understanding how variance of pupil’s’ age affects achievement can be important for countries pursuing the millennium development goals (Hanushek & Woessmann, 2008).

**Statement of the problem**

The teaching of the concept of multiplication is one of the main focus of the primary school mathematics curriculum. However, it has been observed that multiplication has been very difficult for children at the primary level to perform when compared to addition and subtraction. Pupils demonstrate only limited understanding of multiplication which results from their procedural understanding instead of their conceptual understanding. This has resulted to the problem of poor utilization of multiplicative thinking strategy thereby affecting pupils’ future education in mathematics. Hence, Siemon (2004) opined that pupils’ difficulty with higher mathematics is due to lack of multiplicative thinking that aids the conceptual understanding and complete comprehension of the procedures in mathematics. The question therefore is does pupils’ reasoning ability and age determines their multiplicative thinking.

**Purpose of the study**

The study investigated the influence of pupils' reasoning ability and gender on their multiplicative thinking. The study sought to achieve the following.

1. Examine the influence of pupils’ reasoning ability on their multiplicative thinking.
2. Investigate the influence of pupils’ age on their multiplicative thinking.
Research questions
1. To what extent does reasoning ability of pupils influence their multiplicative thinking?
2. What influence does pupils’ age have on their multiplicative thinking?

Statement of hypotheses
1. There is no significant influence of pupils’ reasoning ability (high, average, low) on their multiplicative thinking.
2. Pupils’ age does not significantly influence their multiplicative thinking.

Literature Review
**Reasoning Ability and Pupils' Multiplicative Thinking**
The concept of reasoning ability in relation to teaching and learning is very important to understanding different pupils and their academic achievement. Its development in individuals has always been recognized as enabling pupils to decide intelligently, and work out problems well. Talking about the significance of the development of reasoning in pupils, Malaysia Curriculum Development Centre brought in reasoning skills as one of the main skills to be added in the secondary schools revised science curriculum which was adopted in 2003 (Parmjit, 2003). Ability simply refers to somebody being able to do something. The concept of intelligence refers to mental ability or reasonability and to individual differences related to them (Wikipedia, 2010). According to Woolfolk (2006), intelligence is a basic capacity that influences performance on all activities that are cognitive in nature, from mathematical computing to poetry writing. Woolfolk (2006) stated that the evidence came from a study which was found to have a high correlation among the different instruments use for measuring intellectual capacity.

For students to be able to solve problems in mathematics successfully, Akpan (1996) maintained that they needed to possess the following abilities which constituted what was generally referred to as mathematics ability:
1. Ability to read and comprehend what the problem is required to find;
2. Ability to relate the problem to a previous one or recall facts, theorem, formulae or experiences that are relevant to the problem in hand;
3. Ability to translate the problem from English sentence to mathematics symbolism;
4. Ability to determine the most appropriate operations in solving the problem;
5. Ability to carry out correct computational procedures to arrive at the desired solution;
6. Ability to check the solution in order to validate, improve, generalize and or consolidate what else might be learned (p.26)

Research works have showed that positive correlation existed between students’ reasoning capacity and their understanding of science and mathematics (Oliva, 2003; Sungur & Tekkaya, 2003; Arnold, 2004). Croker & Buchanan (2011) opined that reasoning ability of pupils’ best predicts their achievement mathematics. Croker and Buchanan (2011) further stated that scientific thinking and reasoning skills underpin achievement in science and mathematics education, and the development of these skills is fundamental to becoming a scientifically literate adult.

One way to group students for instructions or class work is to base the grouping on intelligence quotient (I.Q) of the students. In this way, students are classified roughly into high ability group, average (middle) ability group and low ability group based on their performance in a standardized mental ability test. Saleh, Saleh, Rahman and Mohamed
(2010) diagnosed the misunderstanding of pupils' multiplication concept in primary two in Sabah. The results also revealed that mathematics capability had an important influence on the diagnostic mathematics test performance. Pupils with high ability performed far better in the conceptual questions than those of the average and low ability.

Mulligan (2002) investigated the activities of structure in the development of pupils' multiplicative thinking. A case study of twenty four pupils that represented extremes in mathematical ability was adopted for the study. Data were drawn using a longitudinal study from the students through year 2 to year 5 of teaching. Results indicated that low capability students represented multiplicative situations without structure and development progressively from the use of pictorial to iconic representation from year 2 through year 5. On the other hand, high capability students used notational representations with properly developed structures, and lively imagery features strongly in their answers.

Age and Pupils' Multiplicative Thinking
Age refers to the length of time that a person or thing has existed. It is the duration, measure or length of time of the existence of a person, animal, vegetable and object. This study refers to age as the grouping into classes of school learners as corresponding to Jean Piaget's stage of cognitive, mental or intellectual development. Enang (2006) described Piaget's concrete operational stage of seven to eleven years as the age of the Nigerian primary school pupils. The formal operational stage of eleven years upwards is the age of the secondary students. The exact age range however varies from area to area. Most children are noted to enter public education in Bayelsa State at four years in Primary one. Preliminary observation shows that children are divided by age groups into classes. In Bayelsa State there are no compulsory public pre-primary programmes. Children are customarily advanced together from one class to the next class as a single “class” upon reaching the end of each school year. In line with the Federal Government of Nigeria (2013), the Bayelsa State government has made primary education tuition free, universal and compulsory for every Bayelsan child. Educational services like school library, educational resource centres and specialist teachers of particular subjects are provided to suit the interest and age of its primary school learners (Bayelsa State Universal Basic Education Board, 2012).

There is a differing opinion as to how age influences the academic achievement of students, that is, whether increasing age has an influence on students’ academic competency. National Centre for Education Statistics’ (2011) reported that a group of researchers stressed that age influences academic achievement. This was illustrated in their study when the national assessment of educational progress was administered to 7,000, 4th-grade pupils, 9,500 8th-grade students and 10,000 12th-grade students. The area of assessment was geographical. Students in each grade were given questions to ascertain their knowledge in three major areas: space and place, environment and society, and spatial dynamics and connections. A basic level appraisal indicated that the students had partially mastered the knowledge and skills necessary for proficient work at each grade level. In the 2010 geography study, 79% of 4th-grade students, 74% of 8th-grade students and 70% of 12th-grade students scored at or above the basic level. The researchers indicated that increase in age of students has a negative effect on their academic achievement.

Researches done by other groups, however, asserted that the opposite is true. In 1990, a study was conducted to find whether age impacts the academic achievement of students (Zimmerman, 2001). The participants in the study included students in the 5th, 8th, and 11th grades; these students were individually tested by an interviewer who asked the students...
questions designed to measure basic mathematical and verbal knowledge for their age group. Verbal results revealed significantly higher scores for 11th graders than 8th graders, who in turn had scores significantly higher than 5th graders. The results in mathematics were similar to that of verbal, although insignificant disparity existed between the basic knowledge of 11th-grade and 8th-grade students. It seems that in regard to the question whether age affects academic accomplishment of students, the consensus is that is does. However, the question which is insufficiently studied is, how age affects academic achievement. Further research is needed to hold up either a positive or negative association between increasing age and students’ achievement. Brauwer, Verguts and Fias (2006) investigated the development of basic influences that is found in single-digit multiplication. Their focus was on the recovery of simple multiplication process. The participants were of age 7 –, 10 – and 11 years-olds and adults. The results among others revealed that 11-year old pupils’ achievement did not significantly change from that of the adults on single-digit multiplication arithmetic. Significant differences occur with those below 11 years of age.

METHODOLOGY

Research Design
The research design used for this study was the ex-post facto design. According to Kpolovie (2010), ex-post facto research is a methodological approach for eliciting possible or probable antecedent of events that have occurred already and which cannot be subjected to the direct rigorous manipulation and control by the researcher. The researcher used this design because the independent variables which are reasoning ability and ages of pupils were variables that have occurred already and the researcher had no direct control over them.

Population
The population for the study consisted of all basic five and six pupils in the 537 public primary schools in Bayelsa State in 2012/2013 session. They were 108, 741 pupils of which 54,037 were males and 54,704 were females (Bayelsa State Universal Basic Education Board (BSEBU), 2012). The focus on basic five and six pupils was because they must have gone through the concept of multiplication considering the primary school curriculum in mathematics.

Sampling technique
The disproportional stratified random sampling technique was used for the study. The strata were based on the eight educational zones. The subsample fractional selection resulted to Ten (10) public schools randomly selected from each educational zone as shown in table 1. Fourteen (14) pupils were selected using simple random technique (hat and draw) from each class of basic 5 and 6, making a total number of 28 pupils from each school. This resulted to a total of 2,240 pupils from the eighty (80) schools since the educational zones are eight (8).

Sample
A total of 2,240 pupils were used for the study. This constitutes 2% of the population. According to Isangedighi, Joshua, Asim and Ekuri (2004), a proportion of 2% may be adequate for a population of about 200,000 pupils considering the cost of producing and distributing copies of questionnaire to everyone in the population. The spread of the sample of pupils is shown in Table 1.
**Instrumentation**

Two instruments were used for data collection. Multiplicative thinking performance test (MTPT) for basic 5 and 6 pupils and Reasoning ability test (RAT) for basic 5 and 6 pupils. The multiplicative thinking performance test (MTPT) was used to measure pupils’ multiplicative thinking level. The gathering of data in regard to how pupils think of multiplication generally comes from checking and categorizing pupils' answers to problem situation. The methods pupils use in solving problems is considered a hint of their reasoning about the problem. Mulligan and Mitchelmore (1997) Ell, Irwin & McNaughton (2004) showed that pupils' method of solving problem determine the strategy they use, thus gives information about their thinking. The content of the test covered multiplication and division in primary mathematics. The researcher-constructed instrument comprised of demographic variables of the respondents in section A, that is, name of school, sex and age of pupils; section B comprised of 20 questions. In order to ascertain the multiplicative thinking of the pupils, they were asked to show proper working in each of the given problems. The direction of their thinking was obtained from the strategy applied in arriving at the solution.

Ability test measured pupils’ conceptual, vital and rational reasoning capacity. This was on how fine a pupil can development oral and quantitative information, construe data, resolve problems and reason decisively. The questions asked demanded the pupils to relate and put together his/her knowledge of reading and mathematics. The Reasoning Ability Test (RAT) was used to measure the ability level of the pupils. The test result was used to categorize pupils into high, average and low reasoning ability using quartile deviation. The content consisted of general reasoning ability questions in mathematics and quantitative reasoning. It comprised of two sections. Section A, personal data of the respondents and section B, fifty multiple-choice items. Each item had four options with only one correct answer.

The validity of the instruments were assessed by two measurement and evaluation experts in the University of Uyo, and the two experts in Mathematics Education in the University of Calabar. The content validity of the multiplicative thinking performance test was ascertained by the use of the test blueprint as showed in Table 1.

**Table 1**

**Table of test blueprint for multiplicative thinking performance test**

<table>
<thead>
<tr>
<th>Content Unit</th>
<th>Knowledge 25%</th>
<th>Comprehension 20%</th>
<th>Application 55%</th>
<th>Total Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number &amp; Numeration</td>
<td>15% 1</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Basic Operations</td>
<td>30% 1</td>
<td>1</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Measurement</td>
<td>55% 3</td>
<td>2</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>5</td>
<td>11</td>
<td>20</td>
</tr>
</tbody>
</table>

As shown in Table 1, the questions were 15% on number and numeration, 30% on basic operation and 55% on measurement. Knowledge constituted 25%, Comprehension 20% and Application 55% of the total questions. Application constituted 55% because more of the application problems dealt with thinking. The table of specification was considered on three levels due to the level of the students. This was because setting questions on the higher order
of the table of test blueprint will result to higher mathematics concepts which will be above
the level of primary school pupils. The content validity of the reasoning ability test was also
ascertained by the use of test blueprint as shown in Table 2 below.

Table 2
Table of test blueprint for reasoning ability test

<table>
<thead>
<tr>
<th>content unit</th>
<th>knowledge</th>
<th>comprehension</th>
<th>application</th>
<th>total items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number &amp; Numeration</td>
<td>14%</td>
<td>2%</td>
<td>3%</td>
<td>7</td>
</tr>
<tr>
<td>Basic Operations</td>
<td>40%</td>
<td>8%</td>
<td>6%</td>
<td>20</td>
</tr>
<tr>
<td>Measurement</td>
<td>16%</td>
<td>2%</td>
<td>5%</td>
<td>8</td>
</tr>
<tr>
<td>Algebra</td>
<td>22%</td>
<td>4%</td>
<td>6%</td>
<td>11</td>
</tr>
<tr>
<td>Geometry</td>
<td>8%</td>
<td>0%</td>
<td>4%</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>16%</td>
<td>24%</td>
<td>50</td>
</tr>
</tbody>
</table>

From Table 2, application constituted 48%. This is because reasoning ability has to do more
with application of mathematical problems since the test is to ascertain level of pupils’
reasoning ability. Basic operation constituted 40% because basic operation is concerned with
more of signs (addition, subtraction, multiplication and division). The content validity of the
instruments was ascertained by the use of the test blue print and researcher’s supervisors who
are experts in mathematics education. The experts assessed the following:
i. Relevance of the item in relation to the cognitive level and measure of ability
ii. The adequacy of the items to measure the areas of primary mathematics they purport
to measure.

All the corrections and comments of the validators were effected and incorporated into the
final form of the instrument. The reliability of Multiplicative Thinking Performance Test
(MTPT) and Reasoning Ability Test (RAT) were determined using the Kuder-Richardson
formula 20 (K-R20) after subjecting the instruments to a trial test of 40 pupils (20 basic 5 and
20 basic 6). The instruments were presented to a sample of pupils who were not part of the
study but had relevant qualities as those in the study. Reliability coefficients of 0.80 and 0.85
were obtained for MTPT and RAT respectively. The reliability of Students’ Variable
Question (SVQ) was determined using the Cronbach coefficient alpha formula after
administering the instrument to the trial group. A reliability coefficient of 0.75 was obtained
for self-concept, 0.82 for attitude and 0.82 for pupils’ parental socio-economic background.
The reliability for SVQ was 0.89. The reliability coefficients of the instruments obtained
were considered high enough, showing that, the instruments were reliable.

Data collection procedure and analysis
The instruments for this study were administered by the researcher and research assistants.
Permission from the respective primary school headmaster was sought. The instruments were
administered to the pupils in their different schools. The relevant instructions were given to
the pupils. The pupils were allowed to fully complete the SVQ while the MTPT and RAT
were timed forty minutes and one hour respectively. In order to match the questionnaire and
test, pupils were assigned some numbers for identification purposes. The instruments were
fully retrieved from the pupils, one after the other by either the researcher or research
assistants to ensure 100% recovery. The statistical procedures adopted for the analysis of data
collected for the hypotheses were mean, standard deviation and analysis of variance.

Results
Results

Research Question One: What is the influence of pupils’ reasoning ability (high, average, low) on their multiplicative thinking?

Table 3
Mean and Standard Deviation of Pupils' Multiplicative Thinking Based on Their Reasoning Ability

<table>
<thead>
<tr>
<th>Reasoning Ability</th>
<th>N</th>
<th>X</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>546</td>
<td>12.76</td>
<td>2.81</td>
</tr>
<tr>
<td>Average</td>
<td>776</td>
<td>11.76</td>
<td>2.85</td>
</tr>
<tr>
<td>Low</td>
<td>918</td>
<td>10.45</td>
<td>2.91</td>
</tr>
</tbody>
</table>

As showed in table 3, pupils having high reasoning ability level had a mean of 12.76, those having average reasoning ability level had a mean of 11.76 and those having low had a mean of 10.45. It can be inferred from the result that pupils having high ability had the best performance in the multiplicative thinking test, followed by pupils with average reasoning ability level while those with low reasoning ability level had the least performance.

Research Question Two: What is the influence of pupils' age on their multiplicative thinking?

Table 4
Mean and Standard Deviation of Pupils' Multiplicative Thinking Based on Their Age

<table>
<thead>
<tr>
<th>Age</th>
<th>N</th>
<th>X</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 8 years</td>
<td>726</td>
<td>11.12</td>
<td>2.99</td>
</tr>
<tr>
<td>8 -12 years</td>
<td>908</td>
<td>11.56</td>
<td>2.95</td>
</tr>
<tr>
<td>Above 12 years</td>
<td>606</td>
<td>11.74</td>
<td>3.09</td>
</tr>
</tbody>
</table>

As showed in table 4, pupils below the age of 8 years had a mean of 11.12, those from 8 - 12 years had a mean of 11.56 and those above 12 years had a mean of 11.74. It can be inferred from the result that pupils above 12 years had the best performance in the multiplicative thinking test, followed by pupils from the ages of 8 - 12 years while those below the age of 8 years had the least performance.

Hypotheses Testing

Hypothesis One: There is no significant influence of pupils’ reasoning ability (high, average, low) on their multiplicative thinking.

This hypothesis was tested using the analysis of variance as shown in Table 5.
Table 5
Analysis of variance of pupils’ multiplicative thinking test performance classified by reasoning ability.

<table>
<thead>
<tr>
<th>Pupils’ Reasoning Ability</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Fcal</th>
<th>Fcri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>1922.11</td>
<td>2</td>
<td>961.06</td>
<td>117.10*</td>
<td>.300</td>
</tr>
<tr>
<td>Within Groups</td>
<td>18359.51</td>
<td>2237</td>
<td>8.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20281.62</td>
<td>2239</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant at .05 level of significance.

The calculated F-value (117.10) is greater than the critical table (3.00). Therefore, the null hypothesis is rejected. This implies that there exists a significant influence of pupils’ reasoning ability on their multiplicative thinking. In order to determine the direction of significance, a Scheffe’ posthoc pairwise comparison test was done and the results are summarized in Table 6.

Table 6
Summary of scheffe’ posthoc comparison of pupils’ multiplicative thinking test performance classified by reasoning ability

<table>
<thead>
<tr>
<th>(I) Pupils’ Reasoning Ability</th>
<th>Pupils’ N</th>
<th>X</th>
<th>(J) Pupils’ Reasoning Ability</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sign at P &lt; .05</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>546</td>
<td>12.76</td>
<td>Average</td>
<td>1.00*</td>
<td>.160</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low</td>
<td>2.31*</td>
<td>.155</td>
<td>.000</td>
</tr>
<tr>
<td>Average</td>
<td>776</td>
<td>11.76</td>
<td>High</td>
<td>-1.00*</td>
<td>.160</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low</td>
<td>1.31*</td>
<td>.140</td>
<td>.000</td>
</tr>
<tr>
<td>Low</td>
<td>918</td>
<td>10.45</td>
<td>High</td>
<td>-2.31*</td>
<td>.155</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Average</td>
<td>-1.31*</td>
<td>.140</td>
<td>.000</td>
</tr>
</tbody>
</table>

*Significant at P < 0.05 alpha.

Table 6 showed that the mean score (12.76) of pupils who had high reasoning ability level is greater than the mean score (11.76) of pupils who had average reasoning ability level and the mean score (10.45) of those that had low reasoning ability level. The mean score of those who had average reasoning is greater than those who had low reasoning ability level. Table 6 also showed the mean differences (1.00) for high and average reasoning ability level; 2.31 for high and low ability level, and 1.30 for average and low ability level. The levels of significance displayed in Table 6 indicated that pupils in high reasoning ability level performed significantly better than their counterparts in average and low reasoning ability level. Pupils in average reasoning ability level also performed significantly better than those in low reasoning ability level. This shows that reasoning ability has a significant influence on multiplicative thinking.

Hypothesis Two
Pupils’ age does not significant influence their multiplicative thinking.
This hypothesis was tested using the analysis of variance as presented in Table 7.
Table 7  
Analysis of variance of pupils’ multiplicative thinking test performance classified by age of pupils.

<table>
<thead>
<tr>
<th>Pupils’ Age</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>Fcal</th>
<th>Fcri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>141.14</td>
<td>2</td>
<td>70.57</td>
<td>7.84*</td>
<td>3.00</td>
</tr>
<tr>
<td>Within Groups</td>
<td>20140.48</td>
<td>2237</td>
<td>9.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>20281.62</td>
<td>2239</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at .05 level of significance.

As shown in Table 7, the calculated F-value (7.84) of the main effect of pupils’ age is greater than the critical F-value (3.00). Therefore, the null hypothesis is rejected. This implies that pupils’ age significantly influence their multiplicative thinking. In order to determine the direction of significance, a Scheffe’ posthoc pairwise comparison test was done and the results are summarized in Table 8.

Table 8  
Summary of Scheffe’s posthoc comparison of pupils’ pupils’ multiplicative thinking test performance classified by age of pupils

<table>
<thead>
<tr>
<th>(I) Pupils’ Age</th>
<th>N</th>
<th>X</th>
<th>(J) Pupils’ Age</th>
<th>Mean Difference (I-J)</th>
<th>Std. Error</th>
<th>Sign at P &lt; .05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 8years</td>
<td>606</td>
<td>11.74</td>
<td>8 – 12yrs</td>
<td>- 0.44*</td>
<td>.149</td>
<td>.014</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Above 12yrs</td>
<td>- 0.62*</td>
<td>.165</td>
<td>.001</td>
</tr>
<tr>
<td>8 – 12years</td>
<td>908</td>
<td>11.56</td>
<td>Below 8yrs</td>
<td>0.44*</td>
<td>.149</td>
<td>.014</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Above 12yrs</td>
<td>0.18</td>
<td>.157</td>
<td>.502</td>
</tr>
<tr>
<td>Above 12years</td>
<td>726</td>
<td>11.12</td>
<td>Below 8yrs</td>
<td>0.62*</td>
<td>.165</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8 – 12yrs</td>
<td>0.18</td>
<td>.157</td>
<td>.502</td>
</tr>
</tbody>
</table>

*Significant at P < 0.05 alpha.

Table 8 showed that the mean score (11.74) of pupils whose age were above 12years is greater than the mean score (11.77) of pupils whose age were between 8 – 12years and the mean score (11.12) of those whose age were below 8years. The mean score of those whose age were between 8 – 12years is greater than those whose age were below 8years. Table 8 also showed the mean differences 0.44 for below 8years and 8 – 12years; 0.62 for below 8years and above 12years; and 0.18 above 12years and 8 – 12years. The levels of significance displayed in Table 8 indicated that pupils above 12years performed significantly better than their counterparts below 8years. Also, pupils in 8 -12years performed significantly better than those below 8yrs. Pupils above 12years performed better than those in 8 – 12years. However, the difference was not significant.

**Major Findings of this Study**

1. There exists a significant influence of pupils’ reasoning ability on their multiplicative thinking.
2. Pupils who had high reasoning ability level performed significantly better than their counterparts who had average and low reasoning ability level. Pupils in average
reasoning ability level also performed significantly better than those in low reasoning ability level.

3. Pupils’ age significantly influence their multiplicative thinking.
4. Pupils above 12years performed significantly better than their counterparts below 8years. Also, pupils in 8 - 12years performed significantly better than those below 8yrs.

Discussion of Findings
The findings on reasoning ability level and pupils’ multiplicative thinking indicated that pupils in high reasoning ability level performed significantly better than those in average reasoning ability level and those in low reasoning ability level. Those in average reasoning ability level performed significantly better than those in low reasoning ability level. The results confirm the opinion of Pimta, Tayruakham and Nuangchalert (2009) that reasoning ability plays a vital role in students achievement and those who are unable to attain the least level of reasoning will achieve poorly. The results of the study also affirm the statement of Spiridonov (2006) that reasoning is taken to be an element of a united and universal form of intellectual operation, a distinctive makeup which permits one to synthesize inversions and elucidate a transformation system that helps students to do well. This is due to the fact that students are required to know the principles and concepts taught and apply them to problems they have not encountered before. This involves the capacity to investigate and define relationships among different components of the problem and to ascertain a reasonable way of synthesizing the problem to arrive at an answer. This implies that pupils would rely more on their reasoning capability than on simple reproduction of facts. Saleh, Saleh, Rahman and Mohamed (2010) support the idea that mathematical capacity had an essential effect on Diagnostic Mathematics Test of multiplication scores. Higher scores were seen to be associated with higher mathematical capacity. The high ability pupils’ understandings were found higher than those of the average and weak pupils.

The results on pupils’ age and their multiplicative thinking revealed that pupils above 12years performed better than those from 8 -12years, though not significant but performed significantly better than those below 8years. Pupils from 8 -12years performed significantly better than those below 8years. This could be attributed to the fact that most pupils in the 8 – 12years bracket and above are at the concrete operational/formal operation level, therefore, could perform multiplicative task easily because their reasoning are at higher levels when compared with those below 8years. The result of the study is in line with Brauwer, Verguts and Fias (2006) who opined that 11years old pupils do not differ significantly from adults on single-digit multiplication arithmetic and significant differences occur with those below 11years of age. The result also agrees with the findings of Aiyedun (2007). that, age played an important role in predicting performance of children ability to solve multiplication word problems. However, the result of the findings was contrary to the National Centre for Education Statistics’ (2011) which reported that increase of age has a negative effect on the achievement of pupils.

Conclusion
Based on the findings of this study, it could be concluded that the development of students’ reasoning ability at a certain age becomes very necessary and essential because it helps them develop strategies independent of instruction and keep these strategies as part of their informal knowledge system which help them solve problems without the need for direct instruction from a teacher. Reasoning ability provides students with the opportunity to explore multiplicative thinking in a variety of contexts and in different ways in order to
understand that it is more than just multiplication and division. Reasoning ability and age of pupils are very important factors and should be considered when developing the multiplicative thinking ability of pupils.

**Recommendations**

Based on the findings of the study, the following recommendations were made;

1. Teachers should stress the process of iteration schemes (sees a set, that is, number as a unit and second, the distribution of this quantity across another) which would assist pupils to develop high reasoning ability and make them multiplicative thinkers.

2. Teachers should teach for conceptual understanding and point out the usefulness of the subject rather than teaching for memorization, procedural or mere coverage of the scheme of work. The teachers should also posses a demeanor that should influence pupils towards the class. This would boost the attitude of pupils’ toward the subject.

3. Parents should provide a conducive home environment with appropriate materials such as mathematics textbooks, mathematical games and toys to enhance the development of mathematical thinking.

4. The government, ministry of education and head of schools should ensure that counseling services are provided at school for pupils having problems in multiplication so that such pupils can be attended to through the combined efforts of the school and the home.

**References**


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