International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Model of Students' International Achievement Based on Mathematics Content and Cognitive Domains

Flordeliza P. Ferrer*, Ph.D.

Pamantasan ng Lungsod ng Maynila, Intramuros, Manila, 1002, Philippines

Email: fpf92@yahoo.com.ph

Abstract

The researcher conducted an investigation to examine how the mathematics content and cognitive domains strengthened or supported each other when used as predictor variables of students' international mathematics achievement. In this study, the mathematics content and cognitive domains as defined in the mathematics assessment frameworks designed by Trends in International Mathematics and Science Study (TIMSS) were treated as independent variables while the students' mathematics achievement in the overall served as dependent variable. The content domain refers to the dimension specifying the subject matter to be assessed in mathematics. The cognitive domain refers to the dimension specifying the thinking processes that students are likely to use as they engage with the content. Two groups were formed based on their average percent correct in the overall achievement, classified as below average achievers and above average achievers. Consequently, two regression equations were formulated for each grade level (grades IV and VIII), one for below average mathematics achievers and the other for above average mathematics achievers. Regression results disclosed that *Number*, *Geometric Shapes & Measures*, *Data Display*, and *Knowing* are the predictor variables for above average grade IV achievers while *Number*, *Algebra* and *Geometry are* for above average grade VIII achievers. The mathematics content domain in each grade level constantly contributes significantly to the regression model as compared to the cognitive domain. This investigation revealed that content domain more consistently and strongly supports cognitive domain than the reverse.

Keywords*:* mathematics achievement; mathematics cognitive domain; mathematics content domain.

----

* Corresponding author.

E-mail address: fpf92@yahoo.com.ph.

1. Introduction

Content standards are intended to encourage the utmost achievement of every student. These standards aimed to ascertain what every student can and need to learn in mathematics. The content standards are integrated into content domain by experts in order to have reliable measures of the learners' achievement. The content domain is normally created by combining standards that share similar content characteristics.

In developing mathematical competencies, students need not only understand the mathematics content being assessed, but they also need to have higher cognitive skills. Mathematics requires content to be taught in concurrence with process skills identified as the process standards. These process standards are essential for students to master the mathematics content standards.

Competence in mathematics requires students to develop and link their knowledge of concepts and procedures. Some are good in understanding concepts but cannot work out the details, and some are good in working out details but do not understand the concepts. Students initially build up conceptual knowledge in a domain and then employ this conceptual knowledge to generate and select measures for solving mathematical problems in that domain.

A study of Harks [1] investigated the empirical separability of mathematical content domains, cognitive domains, and content-specific cognitive domains. Results revealed that the content and cognitive domains can each be empirically separated. Content domains were better separable than cognitive domains. A differentiation of content-specific cognitive domains showed the best fit to the empirical data.

Another study conducted by Rittle-Johnson and Schneider [2] showed that there is extensive evidence from a variety of mathematical domains indicating that the development of conceptual and procedural knowledge of mathematics is often iterative, with one type of knowledge supporting gains in the other knowledge, which in turn supports gains in the other type of knowledge. Both kinds of knowledge are intertwined and can strengthen each other over time. At times, conceptual knowledge more consistently and strongly supports procedural knowledge than the reverse.

In this context, the researcher conducted an investigation to examine how the mathematics content and cognitive domains strengthened or supported each other when used as predictor variables of students' international mathematics achievement. In line with the TIMSS 2011 [3] dedication to improve teaching and learning in mathematics and science, findings of this study may provide insights to future participants of any mathematics competitions especially in the international context.

2. Materials and Methods

The researcher used the published International Results in Mathematics, Trends in International Mathematics and Science Study (TIMSS) 2011 which considered in the frameworks the mathematics assessment organized in two dimensions: the content and cognitive domains.

Following the TIMSS definition, the content domain refers to the dimension specifying the subject matter to be assessed in mathematics. The content domain at the fourth grade level includes *Number*, *Geometric Shapes & Measures*, and *Data Display*; and the content domain at the eighth grade level includes *Number*, *Algebra*, *Geometry*, and *Data & Chance* [3].

The cognitive domain refers to the dimension specifying the thinking processes that students are likely to use as they engage with the content. The same cognitive domain in the fourth and eight grade levels are considered, namely, *Knowing* (knowledge base of mathematics facts, concepts, tools, and procedures), *Applying* (ability to apply knowledge and conceptual understanding in a problem situation), and *Reasoning* (goes beyond the solution of routine problems to encompass unfamiliar situations, complex contexts, and multi-step problems) [3].

In this study, the mathematics content and cognitive domains were treated as independent variables and the overall mathematics achievement as the dependent variable. Two regression equations were formulated for each grade level (grades IV and VIII), one for below average achievers and the other for above average achievers. The two groups of achievers were formed depending on their average percent correct in the overall achievement, whether they fall below or above average.

To conduct the investigation scientifically, the researcher employed the statistical parameters t-test, coefficient of determination, and F-test. The t-test was used to determine whether each coefficient of the independent variables in the regression equation is useful in estimating the value of the dependent variable. The coefficient of determination R^2 was calculated to compare the estimated and actual value of the dependent variable and examine as well if the regression equation is helpful or not in predicting the y-value. The F statistic was computed to find out whether the observed relationship between the dependent and independent variables occurs by chance.

Finally, the researcher examined the regression results and determined whether the mathematics content and cognitive domain variables in the models consistently strengthened or supported each other when used as predictor variables of students' overall achievement, both for below and above average achievers of grades IV and VIII. There might be other components of cognitive and content domains, however, only those included in the TIMSS 2011 mathematics assessment frameworks were considered in this study.

3. Results and Discussion

3.1. Below Average Grade IV Mathematics Achievers

The regression results for below average grade IV mathematics achievers posted positive regression weights in *Number* (0.5144), *Geometric Shapes & Measures* (0.3791), *Data Display* (0.1403), and *Knowing* (0.0329). This indicates that students with higher scores on this domain are expected to have higher achievement, after controlling for the other variables in the model. Contrary to this, *Applying* (-0.0600) and *Reasoning* (-0.0156) posted negative regression weights (Table 1).

Table 1. Regression Results for Below Average Grade IV Mathematics Achievers

Parameter	Content Domain			Cognitive Domain			Constant
	Number	Geometric Shapes & Measures	Data Display	Knowing	Applying	Reasoning	
coefficient	0.5144	0.3791	0.1403	0.0329	-0.0600	-0.0156	0.0019
std error	0.1829	0.1475	0.0524	0.1443	0.1741	0.0884	0.4810
t-value	2.8122	2.5700	2.6787	0.2276	-0.3448	-0.1765	0.0039
p-value	0.0051	0.0087	0.0069	0.4110	0.3671	0.4310	0.4985
conclusion	S	S	S	NS	NS	NS	NS

Legend: S-significant; NS-not significant

Moreover, taking into consideration their corresponding standard errors, significant p-values < 0.05 were shown in *Number* (0.0051), *Geometric Shapes & Measures* (0.0087), and *Data Display* (0.0069). On the other hand, insignificant p-values > 0.05 were displayed in *Knowing* (0.4110), *Applying* (0.3671), and *Reasoning* (0.4310). This implies that only the content domain (*Number*, *Geometric Shapes & Measures*, and *Data Display)* contribute significantly to the regression equation.

The multiple regression model for below average grade IV achievers expressed as $y = 0.5144x_1 + 0.3791x_2 + 0.1403x_3 + 0.0329x_4 - 0.0600x_5 - 0.0156x_6$ produced a coefficient of determination $R^2 = 0.9991$ indicating almost perfect relationship among the variables. The F value (2,914) with the corresponding p-value of < 0.0001 made an affirmation that the observed relationship between the dependent and independent variables occurred not by chance (Table 2).

3.2. Above Average Grade IV Mathematics Achievers

Positive regression weights in all domains were shown in the regression results for above average grade IV mathematics achievers. *Number* (0.3365) and *Knowing* (0.1931) registered the highest weights in the content and cognitive domains, respectively (Table 3).

Considering their respective standard errors in the computation of t-values, significant p-values < 0.05 were recorded in *Number* (0.0069), *Geometric Shapes & Measures* (0.0220), *Data Display* (0.0114), and *Knowing* (0.0298). On the other hand, insignificant p-values > 0.05 were posted in *Applying* (0.3602) and *Reasoning* (0.0667). Thus, only *Number*, *Geometric Shapes & Measures*, *Data Display*, and *Knowing* contribute significantly to the regression equation.

Table 2. Significance of the Coefficient of Determination and F-value for Below Average Grade IV Mathematics Achievers

Parameter	Value	Conclusion
Coefficient of determination (R^2)	0.9991	Perfect Correlation
F-value p-value	2,914 <0.0001	Significant

For the group of above average grade IV achievers, the multiple regression model expressed as $y = 0.3365x_1 + 0.1878x_2 + 0.1326x_3 + 0.1931x_4 + 0.0521x_5 + 0.0834x_6$ produced a coefficient of determination $R^2 = 0.9981$ indicating almost perfect relationship among the variables. The F value (1,636) with the corresponding p-value of < 0.0001 made an affirmation that the observed relationship between the dependent and independent variables took place not by chance (Table 4).

The regression tables for below and above average grade IV mathematics achievers revealed that the two groups have almost the same predictor variables except for *Knowing*. It is essential to note that the outcomes of this study supports the findings of several researchers who disclosed in their studies that *Number*, *Geometric Shapes & Measures*, *Data Display*, and *Knowing* are considered predictors of students' achievements in mathematics.

*Numbe*r-related topics and mathematics achievement was studied in 2010 by N. Jordan, J. Glutting and C. Raminenie [4] where they examined symbolic number sense with competencies related to counting, number knowledge and arithmetic operations together with mathematics achievement. They learned that number sense made a unique and meaningful contribution to the variance in mathematics achievement and that number sense was found to be most strongly related to the ability to solve applied mathematics problems. In 2011, M. Libertus, L. Feigenson and J. Halberda [5] found that children's approximate number system acuity was correlated with their mathematics ability, even when age and verbal skills were controlled for. The said findings provided evidence for a relationship between the primitive sense of number and mathematics ability starting early in life.

Geometry-related topics and mathematics achievement was studied in 2008 by R. Hannafin, M. Truxaw, J. Vermillion and Y. Liu [6] where they investigated the effects of student spatial ability and type of instructional program on geometry achievement. They found out that students with high spatial ability performed significantly better than did low-spatial learners in instructional treatments, both in dynamic geometry program and geometry tutorial. On the same year, R. Bulla [7] examined whether measures of short-term memory, working memory, and executive functioning predict proficiency in mathematical achievement. Visual-spatial short-term memory span was found to be a predictor in their study specifically of mathematics achievement.

Table 3. Regression Results for Above Average Grade IV Mathematics Achievers

Parameter	Content Domain			Cognitive Domain			Constant
	Number	Geometric Shapes & Measures	Data Display	Knowing	Applying	Reasoning	
coefficient	0.3365	0.1878	0.1326	0.1931	0.0521	0.0834	0.4631
std error	0.1269	0.0885	0.0546	0.0979	0.1440	0.0538	0.8916
t-value	2.6517	2.1213	2.4264	1.9735	0.3619	1.5512	0.5194
p-value	0.0069	0.0220	0.0114	0.0298	0.3602	0.0667	0.3040
conclusion	S	S	S	S	NS	NS	NS

Legend: S-significant; NS-not significant

Table 4. Significance of the Coefficient of Determination and F-value
for Above Average Grade IV Mathematics Achievers

Parameter	Value	Conclusion
Coefficient of determination (R^2)	0.9981	Perfect Correlation
F-value p-value	1,636 <0.0001	Significant

Data display-related topics, specifically on statistics achievement was studied in 2003 by D. Bandalos, S. Finney and J. Geske [8] where they explored on structural equation modeling techniques to test a model of statistics performance based on achievement goal theory. Both learning and performance goals affected achievement indirectly through study strategies, self-efficacy, and test anxiety. In 2004, A. Furnham and T. Chamorro-Premuzic [9] examined the relationship between psychometrically measured individual differences and several cognitive ability tests, and statistics examination grades of students. A series of bivariate and partial correlations done in their study showed that there were significant and positive associations between statistics examination grades and psychometric intelligence, notably spatial ability.

Knowledge-related topics and mathematics achievement was studied in 2008 by T. Hailikaria, A. Nevgia and E. Komulainen [10] where they discovered the relationships between prior knowledge, academic self-beliefs, and previous study success in predicting the achievement of students in mathematics. Structural equation modeling was used to explore the interplay of these variables in predicting student achievement. The results revealed that domain-specific prior knowledge was the strongest predictor of student achievement over and above other variables included in the model. On the same year, T. Hailikari, N. Katajavuori and S. Lindblom-Ylanne [11] analyzed how prior knowledge from previous subjects influences student achievement in a more advanced subject, and secondly, determined whether the learned knowledge is retained as the students' education proceed. The results disclosed that prior knowledge from previous subjects significantly influenced student achievement. Likewise, the investigation showed that procedural knowledge was especially related to student achievement.

3.3. Below Average Grade VIII Mathematics Achievers

Findings of this study revealed that the regression results for below average grade VIII mathematics achievers displayed positive regression weights in all domains except in *Number* (-0.0295). It may be noted that the variables in the cognitive domain provided the highest positive weights: *Applying* (0.3587), *Knowing* (0.3336), and *Reasoning* (0.2112). This indicates that students with higher scores on the cognitive domain are expected to have higher achievement, after controlling for the other variables in the model (Table 5).

Employing their corresponding standard errors, significant p-values < 0.05 were computed in *Knowing* (0.0286) and *Applying* (0.0234). On the contrary, insignificant p-values > 0.05 were displayed in *Number* (0.4155), *Algebra* (0.3193), *Geometry (*0.4914), *Data & Chance* (0.2299), and *Reasoning* (0.0807). This implies that only *Knowing* and *Applying* contribute significantly to the regression equation.

Table 5 shows the regression results for below average mathematics achievers from the eight grade level.

Table 5. Regression Results for Below Average Grade VIII Mathematics Achievers

Parameter	Content Domain				Cognitive Domain			Cons-tant
	Number	Algebra	Geome-try	Data & Chance	Knowing	Applying	Reaso-ning	
coefficient	-0.0295	0.0598	0.0023	0.0553	0.3336	0.3587	0.2112	0.0012
std error	0.1361	0.1255	0.1070	0.0735	0.1662	0.1703	0.1458	0.7476
t-value	-0.2168	0.4762	0.0218	0.7523	2.0073	2.1060	1.4493	0.0016
p-value	0.4155	0.3193	0.4914	0.2299	0.0286	0.0234	0.0807	0.4994
conclusion	NS	NS	NS	NS	S	S	NS	NS

Legend: S-significant; NS-not significant

The coefficient of determination $R^2 = 0.9973$ indicative of almost perfect relationship among the variables was computed for the multiple regression model for below average grade VIII achievers expressed as $y = -0.0295x_1 + 0.0598x_2 + 0.0023x_3 + 0.0553x_4 + 0.3336x_5 + 0.3587x_6 + 0.2112x_7$. The F value (778) with the corresponding p-value of < 0.0001 asserted that the observed relationship between the dependent and independent variables occurred not by chance (Table 6).

Table 6. Significance of the Coefficient of Determination and F-value for Below Average Grade VIII Mathematics Achievers

Parameter	Value	Conclusion
Coefficient of determination (R^2)	0.9973	Perfect Correlation
F-value p-value	778 <0.0001	Significant

3.4. *Above Average Grade VIII Mathematics Achievers*

The regression results for above average grade VIII mathematics achievers posted positive regression weights in all domains keeping the highest positive weights in the content domain: *Algebra* (0.2794), *Number* (0.2230), *Geometry* (0.1865), and *Data Chance* (0.1411). This means that students with higher scores on this domain are expected to have higher achievement, after controlling for the other variables in the model (Table 7).

Table 7. Regression Results for Above Average Grade VIII Mathematics Achievers

Parameter	Content Domain				Cognitive Domain			Cons-tant
	Number	Algebra	Geome-try	Data & Chance	Knowing	Applying	Reaso-ning	
coefficient	0.2230	0.2794	0.1865	0.1411	0.0190	0.0842	0.0530	1.5950
std error	0.1141	0.1514	0.0742	0.0975	0.1561	0.1650	0.1232	1.5367
t-value	1.9550	1.8456	2.5124	1.4469	0.1218	0.5103	0.4303	1.0379
p-value	0.0336	0.0412	0.0112	0.0831	0.4522	0.3082	0.3362	0.1569
conclusion	S	S	S	NS	NS	NS	NS	NS

Legend: S-significant; NS-not significant

Using their respective standard errors in the computation of t-values, significant p-values < 0.05 were provided in *Number* (0.0336), *Algebra* (0.0412), and *Geometry* (0.0112). On the other hand, insignificant p-values > 0.05 were displayed in *Data & Chance* (0.0831), *Knowing* (0.4522), *Applying* (0.3082), and *Reasoning* (0.3362). This indicates that only the content domain variables except *Data & Chance* contribute significantly to the regression equation.

The multiple regression model for above average grade VIII achievers expressed as $y = 0.2230x_1 + 0.2794x_2 + 0.1865x_3 + 0.1411x_4 + 0.0190x_5 + 0.0842x_6 + 0.0530x_7$ established a coefficient of determination $R^2 = 0.9994$ indicating almost perfect relationship among the variables. The F value (2,530) with the corresponding p-value of < 0.0001 disclosed that the relationship between the dependent and independent variables took place not only by chance (Table 8).

Table 8. Significance of the Coefficient of Determination and F-value
for Above Average Grade VIII Mathematics Achievers

Parameter	Value	Conclusion
Coefficient of determination (R^2)	0.9994	Perfect Correlation
F-value p-value	2,530 <0.0001	Significant

The regression tables for below and above average grade VIII mathematics achievers revealed different results. If cognitive domain (*Knowing and Applying*) significantly contributes to the regression model for below average achievers, on the contrary, the content domain (*Number*, *Algebra* and *Geometry)* is the significant contributor for above average achievers. It is important to note that the outcomes of this study supports the findings of several researchers who also learned in their studies that *Number*, *Algebra* and *Geometry* are considered predictors of students' achievements in mathematics.

Algebra-related topics and mathematics achievement was studied in 2000 by A. Gamoran and E. Hannigan [12] where they examined the impact of high school algebra among students who differ in their mathematics skills prior to entering high school. The regression analysis exposed in their study that all students benefit from taking algebra; among those with very low prior achievement, the benefits are somewhat smaller, but algebra is still worthwhile for all students. Their analysis suggests that a given student who has not taken algebra would have achieved more by doing so. In 2006, F. Spielhagen [13] discovered that students who completed algebra in the eighth grade stayed in the mathematics pipeline longer and attended college at greater rates than those who did not. He further concluded that because of the sequential nature of mathematics course work, students taking algebra at an earlier age have the opportunity to enroll in more advanced courses in the future.

Number-related topics and mathematics achievement was studied in 2011 by D. Geary [14] where he administered in a 5-year longitudinal study the measures of number, counting, and arithmetic competencies and examined whether these could predict mathematics achievement. Early fluency in processing and manipulating numerical set size and Arabic numerals, accurate use of sophisticated counting procedures for solving addition problems, and accuracy in making placements on a mathematical number line were found to be uniquely predictive of mathematics achievement. On the same year, S. Dehaene [15] exposed in his study that a number sense is a powerful source of mathematical intuitions in young children. He learned that differences in individual abilities for arithmetic correspond to differences in number sense. Indeed, he found out that it is even possible to detect such individual differences at the brain level: in early teens, children who score higher on mathematics tests have detectably more efficient connections between the number sense area of the left intraparietal cortex and the frontal lobe. He further concluded that early number sense fosters arithmetic understanding, which itself boosts numerical acuity, in an ever-ascending virtuous spiral.

Geometry-related topics and mathematics achievement was studied in 2003 by J. Sortor and M. Kulp [16] where they discovered that the multiple linear regressions controlling for performance on the visual-motor integration and each subtest, as well as age and verbal cognitive ability showed a significant relation between the visual perception subtest score and mathematics achievement. Their study further concluded that visual perceptual ability should be assessed in children with poor mathematics and/or reading achievement. In 2012, R. Choudhury and D. Das [17] learned the influence of areas in relation to the geometrical ability and study habit on the students' achievement in mathematics. They concluded from their study that the geometrical ability influenced the achievement in mathematics and recommended the inclusion of geometrical curricular programs and workshops to improve the geometrical thinking.

4. Conclusion

The regression equations formulated for the groups belonging to below and above average grade IV mathematics achievers are observed to be similar in terms of the contribution of the regression positive weights. It may be noted that the entire content domain (*Number*, *Geometric Shapes & Measures*, and *Data Display)* contributed significantly in the regression models of the two groups.

Different results, however, were revealed by the regression equations for grade VIII mathematics achievers. If cognitive domain (*Knowing and Applying*) significantly contributed to the regression model for below average achievers, on the contrary, the content domain (*Number*, *Algebra* and *Geometry*) is the significant contributor for above average achievers.

After examining the four regression results, it may be observed that constantly for above average achievers, the mathematics content domain contributes significantly to the regression model as compared to the cognitive domain in the two grade levels. However, it is essential to note as exposed by previous studies that the students' achievement relative to mathematics content and cognitive domains may be considered iterative.

Content domain may be supporting gains in cognitive domain, or may be the reverse. Both kinds of domain are often intertwined and can strengthen each other. This was the case of the grade VIII achievers where regression equation for below average achievers is strengthened by the cognitive domain while regression equation for above average achievers is strengthened by the content domain.

Focusing on the regression results of the above average mathematics achievers, similar to findings of other researches, this investigation revealed that content domain more consistently and strongly supports cognitive domain than the reverse in the two grade levels.

References

[1] B. Harks, E. Klieme, J. Hartig & D. Leiss. “Separating cognitive and content domains in mathematical competence.” *Educational Assessment*, vol.19(4), pp. 243-266, 2014.

[2] B. Rittle-Johnson & M. Schneider. “Developing conceptual and procedural knowledge of mathematics.” In R. Kadosh & A. Dowker (Eds). *Oxford Handbook of Numerical Cognition,* Oxford Press, 2012, pp. 1-22.

[3] TIMSS 2011 Assessment. International Association for the Evaluation of Educational Achievement (IEA). TIMSS & PIRLS International Study Center: Lynch School of Education, Boston College, Chestnut Hill, MA and International Association for the Evaluation of Educational Achievement (IEA), IEA Secretariat, Amsterdam, the Netherlands, 2012.

[4] N. Jordan, J. Glutting & C. Raminenie. “The importance of number sense to mathematics achievement in first and third grades.” *Learning and Individual Differences*, vol. 20(2), pp. 82-88, Apr. 2010.

[5] M. Libertus, L. Feigenson & J. Halberda. “Preschool acuity of the approximate number system correlates with school math ability.” *Developmental Science*, vol. 14(6), pp. 1292–1300, Nov. 2011.

[6] R. Hannafin, M. Truxaw, J. Vermillion & Y. Liu. “Effects of spatial ability and instructional program on geometry achievement.” *The Journal of Educational Research*, vol. 101(3), pp. 148-157, 2008.

[7] R. Bulla, K. Espyb & S. Wiebeb. “Short-term memory, working memory, and executive functioning in preschoolers: longitudinal predictors of mathematical achievement at age 7 years.” *Developmental Neuropsychology*, vol. 33(3), pp. 205-228, 2008.

[8] D. Bandalos, S. Finney & J. Geske. “A model of statistics performance based on achievement goal theory.” *Journal of Educational Psychology*, vol. 95(3), pp. 604-616, Sep. 2003.

[9] A. Furnham & T. Chamorro-Premuzic. “Personality and intelligence as predictors of statistics examination grades.” *Personality and Individual Differences*, vol. 37(5), pp. 943-955, Oct. 2004.

[10] T. Hailikaria, A. Nevgia & E. Komulainen. “Academic self-beliefs and prior knowledge as predictors of student achievement in mathematics: a structural model.” *Educational Psychology: An International Journal of Experimental Educational Psychology*, vol. 28(1), pp. 59-71, 2008.

[11] T. Hailikari, N. Katajavuori & S. Lindblom-Ylanne. “The relevance of prior knowledge in learning and instructional design.” *American Journal of Pharmaceutical Education*, vol. 72(5), pp. 113, Oct. 2008.

[12] A. Gamoran & E. Hannigan. “Algebra for everyone? Benefits of college-preparatory mathematics for students with diverse abilities in early secondary school.” *Educational Evaluation and Policy Analysis*, vol. 22(3), pp. 241-254, Sep. 2000.

[13] F. Spielhagen. "Closing the achievement gap in math: the long-term effects of eighth-grade algebra." *Journal of Advanced Academics*, vol. 18(1), pp. 34-59, 2006.

[14] D. Geary. "Cognitive predictors of achievement growth in mathematics: a 5-year longitudinal study." *Developmental Psychology*, vol. 47(6), pp. 1539-1552, Nov. 2011.

[15] S. Dehaene. The Number Sense: How the Mind Creates Mathematics, Revised and Updated Edition. Oxford University Press, April 2011, pp. 272-273.

[16] J. Sortor & M. Kulp. "Are the results of the Beery-Buktenica developmental test of visual-motor integration and its subtests related to achievement test scores?" *Optometry & Vision Science*, vol. 80(11), pp. 758-763, Nov. 2003.

[17] R. Choudhury & D. Das. "Influence of geometrical ability and study habit on the achievement in mathematics at secondary stage." *International Journal of Computational Engineering Research*, vol. 2(6), pp. 233-237, Oct. 2012.