Human Behavior, Development and Society
ISSN 2651-1762, Vol 20 No 4, December 2019

Mathematics Foundation and Its Role in Determining Student Preparedness for College

Alwyn A. Chacko and Shibi A. Chacko, Lowry Adventist College, India

Abstract

Algebra, the foundation to higher math learning skills, is integral in our daily lives. Therefore it is important to introduce a system that will help algebra become a part of one's intellectual support system to assist with everyday challenges. Every person, even if lacking a formal math education, uses applications such as addition, subtraction, multiplication and division. Basic demographic data and a math placement test for students seeking entry into college, covering algebra and pre-calculus topics, was administered. A comparison of student experience, nationality and gender differences over their performance on the placement test revealed no significant performance differences between genders. However, differences based on nationality and student experience were found from a 2-T, Kruskal-Wallis and Tukey's Honest Significant Difference test.

Keywords: *Gender bias, algebra, math ability, basic foundation, mathematics curriculum*

Introduction and Literature Review

It is reasonable to assume that deficiencies in basic skill areas can impede a student's learning ability and potential. Of prime concern for university educators and administrators are the skill levels of their entering freshmen. Deficiencies in fundamental skill areas negatively affect efficient teaching at the university level, and can seriously impede an individual's ability to progress and succeed (Noser, Tanner, & Shaw, 2008). In the context of this study–a university located in a rural region in Thailand–a mathematics placement test is conducted to assess the level of the incoming students before freshman registration. It has been observed that less than 50% of the freshman cohort successfully pass the expected requirements to begin their college math courses. This is consistent with the findings of Noser, Tanner, and Shah (2008), who found that math performance in the modern era is on a decline. This calls for a closer look at school mathematics curriculum, especially in Asian countries where progress and development is desired.

Firstly, we look at gender differences with respect to mathematics performance. According to Witelson, Glezer, and Kigar (1995), men and women differ not only in their physical attributes, but also in many other characteristics, including learning processes, language development, and the way they solve intellectual problems. Gender differences have been observed in cognitive functioning and brain structure. These differences may be attributed to various genetic, hormonal, and environmental factors, and do not reflect any overall superiority advantage of either sex. Unlike research done in the past, significant differences have been found that were attributed primarily to socio-cultural biases against girls. Over the past 20 years, the fraction of males to females who score in the top five percent in high school math has remained constant at two to one (Xie & Shauman, 2003). Examining students who scored 800 on the math SAT in 2007, Ellison and Swanson (regarding this issue) also found a two to one male–female ratio.

There are nations which have recognized the needs to bolster students' mathematics proficiency. In Singapore, for example, the math curriculum brings into focus the importance of problem-solving skills, which are believed to be central to mathematics learning. It involves the acquisition and application of mathematics concepts and skills in a wide range of situations, including non-routine, open-ended, and real-world problems. The development of mathematical problem-solving ability is dependent on five interrelated components, namely: concepts, skills, processes, attitudes, and metacognition (CPPD 2006).

In the U.S., on the other hand, Woodward and Montague (1997) examined efforts to reform math instruction, with special emphasis on students with learning disabilities. The capability of American students has also been examined at a broader level. In particular, a series of international studies (e.g., Third International Mathematics and Science Study or TIMSS; National Research Council (1997) and subsequent TIMSS-Repeat, 1999), which involve about 40 countries confirmed that students in the U.S. do not perform as well as students in many other developed countries, especially Asian countries. In 1999, U.S. students were in about the middle as compared with 38 participating countries. The top performing countries were Singapore, Republic of Korea, Chinese Taipei, Hong Kong, Japan, and Belgium. As Schmidt and his colleagues (Schmidt, McKnight, Valverde, Houang, & Wiley, 1997) suggested, mathematics instruction in the U.S. suffers from a "splintered vision," with curricula that focus on too many superficially taught topics in a given year.

We also looked at the performance according to nationality–primarily those studying in the host country, Thailand – along with China, Indonesia, Malaysia, Myanmar, other Asian countries (India, Korea, Laos, Philippines, Singapore, and Vietnam) and other continents (students from Africa or Europe). The socio-cultural, economic, and political framework of a country has an influence on the performance of its students. According to a study by Wüstenberg, Greiff, Molnar, and Funke (2014) concerning mean performance in complex problem solving, the researchers expected that German and Hungarian students would not differ significantly. However, latent mean differences between Germans and Hungarians indicated that Germans performed significantly better in knowledge acquisition. As Roth and Garnier (2006) mentioned, when complex problem solving is not covered, this neglect of problem-solving skills could place U.S. students at a disadvantage compared with their peers in countries where teaching and tests emphasize content that is more challenging. The nationality, which reflects a curricular structure along with other influencing factors, does have an effect on student performance, especially in the field of mathematics learning.

The research objective is to investigate students' math preparedness before entering college. In pursuit of this objective, it will help decipher the shortcomings in student math knowledge and skills. This will bring to light a systemic problem, and an alarm will be raised before the problem grows out of proportion and cannot be controlled, so that a solution may be synthesized in time.

Research Questions

1. Is math performance influenced by gender?
2. Does nationality show a significant difference in math learning ability performance among students?
3. What is the perceived level of student math experience as compared to their math ability as predicted by a university Math placement test?

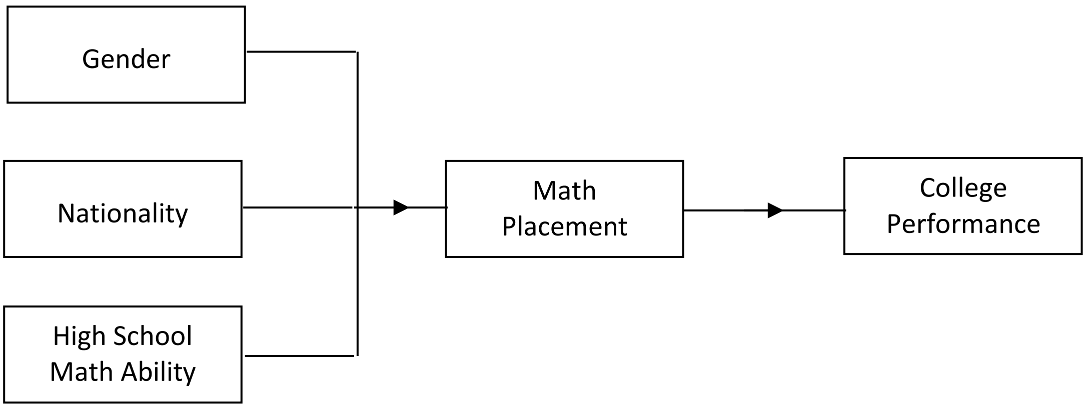

Figure 1. Framework of the Study

Method

At the university where the data was gathered, international program students participated in a math placement test during the admission process. Along with the test, the students are asked to fill in a survey instrument which covers personal demographic details, as well as questions that describe their experience studying mathematics in high school. The answer options pertain to the level of difficulty, and self-evaluation.

The math placement test consisted of thirty questions which were divided into three sections: Algebra One level, Algebra Two level, and pre-calculus. The placement test was a multiple-choice instrument, and students were not allowed to use calculators. The test was administered for a duration of one hour. Data was analyzed with a statistical software package. The results of the test were compared with their demographic details. A 2T-test is used to compare the performance of students by gender. A Kruskal-Wallis test–a nonparametric test–was used to determine if there was a statistically significant difference between their math learning experience levels and their nationalities. Their perception of their math learning experience was also compared to their actual performance on the math placement test.

A sample of 112 participants was been collected from students seeking admission to the International program majoring in either Business Administration, Arts and Humanities, Religious Studies, Education and Psychology, and Science. Specifically, the sample contained 48 male and 64 female participants hailing from 14 different countries.

Results

Math performance based on gender is shown in Table 1. The average math score out of a maximum of 30 points showed that male students performed slightly better than did their female counterparts. Their overall performance showed that the average performance was lower than their pass scores. A two-sample t-test did not show any significant differences in performance at the 95% confidence level.

Table 1. Gender and Average Math Scores

Gender	Count	Average MATH Score	St Dev	SE Mean	95% CI for difference	P -Value
Male	48	12.15	6.01	0.87	(-1.10, 3.26) 2T - Test	0.326
Female	64	11.06	5.39	0.67		
Total	112	11.53	5.66	0.54		

Note: Two-sample independent t-test.

Table 2 shows the placement results and grade distribution according to gender. An "A" grade represents those students who scored 60% or higher in the pre-calculus section, and a "B" grade was awarded to those who had a Combined Algebra 1 & 2 score greater than 50%, or an Individual Algebra 1 or 2 score greater 60%. A "C" grade was awarded to those whose scores were less than 50%. The students who passed this exam were those who received a B grade or above, which was 53 over 112 students.

Table 2. Math Placement Exam Scores

Grade	Male		Female		Total	
	Count	Per %	Count	Per %	Count	Per %
A	3	6.25	2	3.13	5	4.46
B	22	45.83	26	40.63	48	42.86
C	23	47.92	36	56.25	59	52.68
Total	48	100.00	64	100.00	112	100.00

Note: A = Pre-calculus Score > 60%
B = Combined Algebra 1 & 2 score > 50% OR Individual Algebra 1 Or 2 score > 60%
C = Combined Algebra 1 and 2 score ≤ 50%

It was found that the higher the level of math difficulty, the lower the students' math scores. The test was divided into three sections: algebra one, algebra two, and pre-calculus. After comparing their performance in these sections, a clear and significant difference was found between them.

Algebra one level showed the best performance compared with algebra two level, and pre-calculus, and algebra two also showed a better performance than pre-calculus.

Students reported their math ability based on their experience with learning mathematics, as shown in Table 3. Four options were presented, and the results show that 44.37% of students expressed that successful math performance is possible (this includes options a. and b.). A one-way ANOVA test was also used on the four levels, and the results showed that there was a significant difference between the math performances of those students who reported, "I do well in math, but I need to study" as compared to the categories of "Not so good" and "Math is very hard for me". The Kruskal-Wallis test had a *p*-value = 0.000, H = 25.83. Table 4 shows a median score of 14.0 for 'b.', as compared to 8.5 each for 'c.' and 'd.'

Table 3. Experience in Mathematics Based on Math Ability

No.	Math Ability	Count	Percentage
1	Math is easy.	3	2.68%
2	I do well but I need to study.	47	41.69%
3	Not so good.	52	46.43%
4	Math is very hard for me.	10	8.93%
Total		112	100.00

*Note: * Math Ability as per student perception*

Table 4. Math Experience Vs Math Scores Achieved

Kruskal – Wallis Test on Scores				
Math Ability	***N***	**Median**	**Ave Rank**	***Z***
A	3	14.0	80.2	1.28
B	47	14.0	73.1	4.60
C	52	8.5	44.4	-3.67
D	10	8.5	34.2	-2.28
Overall	112		56.2	
H = 25.83 *df* = 3 *p* = .00				
H = 25.94 *df* = 3 *p* = .00				

Note: A = Pre-calculus Score > 60%
B = Combined Algebra 1 & 2 score > 50% OR Individual Algebra 1 Or 2 score > 60%
C = Combined Algebra 1 and 2 score ≤ 50%

The maximum score of 14.0 for level "B" assures us that these students do not have high confidence from their past experience in math, but scored less than 50% of the median performance outcome required for entrance into college level mathematic courses. The levels indicated as "C" and "D" were for students who claimed low math skills, and their performance was in accordance with their expectations, for an alarmingly low median score of 8.5. Are math learning difficulties real? These findings are evidence that points in this direction.

Table 5 below shows the distribution of student nationalities. The highest number of students came from Cambodia and Thailand, followed by Malaysia and China.

Table 5. Distribution of Student Nationality and Average Math Placement Scores

	Nationality	Count	Percentage Count	Average Math Score* (Max = 20 Points)
1	Cambodia	17	15.18	10.59
2	China	14	12.50	15.00
3	Indonesia	8	7.14	12.63
4	Malaysia	16	14.29	9.38
5	Myanmar	12	10.71	12.67
6	Other Asian	18	16.07	12.89
7	Other Continents	10	8.93	9.70
8	Thailand	17	15.18	9.94
	Total	112	100.00	

*Note: * Average Math score as per the number of students participated*

The nationality comparison, too, did not show any significant difference in math performance, even though students of Chinese descent have shown a substantially higher performance in the past. In Table 6, the median score of the Chinese students was 14 points out of a maximum of 30 points, whereas the other students had comparatively lower scores. There is a significant difference in the median scores on the Kruskal-Wallis test with a p-value = 0.031 and a H = 12.33. China as a country has shown a significantly high math performance among Asian countries.

Table 6. Nationality versus Math Scores

Kruskal – Wallis Test on Math Scores				
Nationality	**N**	**Median**	**Ave Rank**	***Z***
Cambodia	17	11.0	39.3	-0.60
China	14	14.0	57.0	2.44
Indonesia	8	12.5	49.3	0.83
Malaysia	16	8.5	31.8	-1.95
Myanmar	12	13.0	51.2	1.33
Thailand	17	9.0	34.5	-1.52
Overall	84		42.5	
H = 12.33 *df* = 5 *p* = .031				
H = 12.39 *df* = 5 *p* = .030 (adjusted for ties)				

Note: Test done for Asian nationalities

Discussion

When comparing differences in gender effects, only one variable–student feelings about attending math class–was significantly different between male and female respondents. Though male students had average scores higher than their female counterparts, these differences were not statistically significant. Unlike research done in the past, we can see an improving trend with respect to female students' performance in math. This confirms Witelson et al.'s (1995) finding that there is a significant reduction in the gap between the math foundation and abilities of male and female students. The results did reveal a more disturbing truth–the average scores were very low, and the levels of math ability were very basic. A result such as this prompts many questions regarding the mathematics curricular structure in schools of various nationalities, the role of teachers, national economic status, measures taken to spot and correct math learning difficulties, facilities and resources to help teaching and learning, which are a few of the major factors that may influence low math scores. Students are also lethargic and slow to learn due to factors such as the growing use of technology for entertainment. Students' study patterns have also deteriorated, and this modern trend will certainly pose as a hindrance for traditional forms of mathematics learning.

It is therefore important to relook at the math curriculum in schools, and what is being done to build basic mathematics and algebra foundation. At the entry level into college, every student needs to have a basic math foundation since–as Clark (2008) mentioned–there is a public belief in the importance of mathematics to the growth of national economies, as in the case attributed to Singapore's success.

The level of being unprepared (55.36%) in this sample shows that measures need to be taken to push this group of students to the higher level of expected performance in college. Every major in college requires quantitative skills and rational thinking abilities, and these will affect a student's overall academic performance. There needs to be a concerted effort on the part of academic administrators to advocate and develop a system that addresses math learning disabilities. In 2016 when the author had the opportunity to attend the 8th National Conference on Dyscalculia and Math Learning Difficulties in London, it helped him to appreciate the efforts taken by the UK government to invest in early student development in the area of Math learning difficulties. A considerable amount of research has gone into producing methods, systems, and tangible resources to support this cause. A few of the issues addressed are Mathematics Anxiety, learning challenges, numeration barriers, connecting with support groups, and case studies. In the Asian context, there is a need for responsible governments to invest in this area of concern, and engage with institutions of higher learning to build mechanisms to share approaches and develop teachers to be better prepared to help students develop stronger math skill sets. In the words of Andrew Jeffrey, the keynote speaker, "Students learn a new skill by using concrete materials. Reinforcement is achieved by going back and forth between the representations." (Learning Works, 2016).

Conclusion

In this study, no evidence was found that students choose their majors according to their ability in mathematics. Furthermore, no significant relationship was found between their math scores and choice of major. It can be assumed that while there are both high and low math performers, students make their choice of major based on other factors, and not on their mathematic abilities.
Even though the various nationalities represented in the sample did not show significant differences in their math performance, evidence from countries does show that there are differences in math ability in rapidly growing economies. Asian countries represented in the study have shown poor performance, since most students come from backgrounds with a weak math foundation. As the level of math difficulty increased, their performance drastically decreased, showing that students were undertrained and required remedial intervention before they could be comfortably placed in the math courses required to pursue their major courses of study.

Their confidence levels in math knowledge and application also revealed significant differences, which tells us that students have prior knowledge of their average level of math abilities. These results can be helpful to instructors and departments that are responsible to provide general mathematics courses for various study programs. The results can also be useful to those responsible for developing curricular programs, to restructure the study plan and cater to the needs of the ones who are weak in the subject. An ESL Program, which generally focuses on English speaking, writing, and reading skills could also include math and sciences, since these subjects are taught using the medium of the English language. This would address the use of English vocabulary in math and science classes, and would help improve the math preparedness of incoming students.

The university which was studied accepts international students coming from developing Asian countries, many of which may have similar challenges, and can benefit from the results of this study. As a Christian university, it believes in a holistic approach to life that balances mind, body, and spirit in such a way that students are fully prepared to serve the world when they finish their studies.

Recommendation

Institutions responsible for policy and regulations need to work out a plan to identify, categorize, and prepare interventions to help reduce math-learning difficulties. To help develop student confidence in problem solving and rational thinking, which are vital to student success in quantitative areas of development in the diverse fields of study. Mathematics learning difficulty begins as early as the initial years of school; therefore, it would be good practice if universities could collaborate with schools, identify student difficulties, and take remedial actions to help children overcome their inefficiency before problems escalate. Mathematics learning difficulty–dyscalculia–is a reality, and needs to be addressed before it turns to be an educational epidemic.

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