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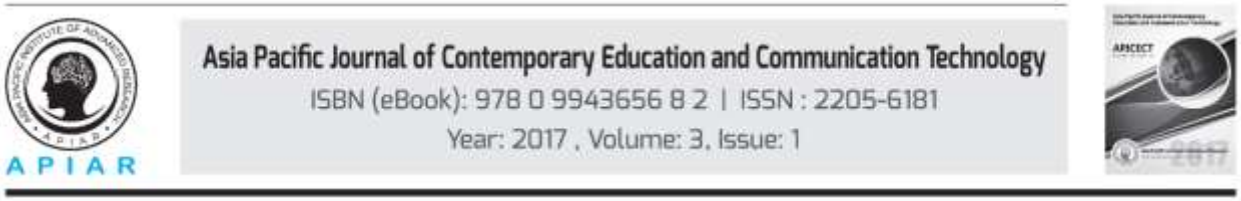

THE IMPACT OF STUDENTS' MATHEMATICS BACKGROUND ON THEIR PERFORMANCES FOR STUDYING COMPULSORY MATHEMATICS/STATISTICS SUBJECTS IN THE COLLEGE

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Abstract

Study of mathematics and statistics is not compulsory in the curriculum of senior secondary education as college freshmen are always having diverse mathematical backgrounds. Educators in Community Colleges in Hong Kong face significant challenges in teaching students, particularly students with lower level of numeracy. In order to better understand students' mathematics/statistics background so as to enhance their quantitative and analytical skills and to be numerically literate, the relationship between students' mathematics/statistics background and their performance in studying the compulsory mathematics/statistics subject in the College is investigated and presented in this paper. A survey was carried out for college freshmen who need to learn a compulsory mathematics and/or statistics subjects in academic year 2011/2012. Information on students' mathematics and statistics background were collected. Details on the quantitative data obtained from the survey were summarized and discussed. Regression analysis was performed to calibrate the relationship. Results show that the relationship between students' mathematics/statistics background and their performance in studying the compulsory mathematics/statistics subject in the College is statistically significant. Analysis of data collected from students contributes to grow evidence that additional support from college to students, particularly those students with lower level of numeracy is of prime need. Moreover, the results give some insight to help college lecturers to explore multiple ways to assist students in strengthen their numeracy. Thus, it is hoped that with better understanding of the students' mathematics and statistics background would contribute to students' learning effectiveness by improving their mathematical ability, their learning in the college and lifelong learning ultimately.

Keywords: Mathematics, Statistics, Numerate Literacy, and Learning

1. Introduction

Transition to sub-degree education involves academic challenges for the majority of students, and the move to tertiary mathematics appears to present particular hurdles. The mathematical barriers are mainly caused by two factors, the steady decline in basic mathematical skills (Hawkes & Savage, 2000) and the different natures of secondary school mathematics and the mathematics at tertiary level (Luk, 2005). Tertiary institutions address the under-preparedness in mathematics of the incoming students with various support facilities, such as remediation programmes, learning support centres, etc. (Perkin, Pell & Croft, 2007; MacGillvray, 2009). Enormous effort have been made in providing these support services and it is gratified that the efforts made seem to be justified, some students who have done little or no mathematics at all in

senior secondary school, take the opportunities available to re-engage with mathematics and succeed in their mathematics learning (Varsavsky, 2010).

The Education Bureau (Education Bureau, 2010) stated in the common descriptors of Associate Degree (AD) and Higher Diploma (HD) Programmes that one of the learning outcomes of AD/HD programme is to equip students with "A solid foundation of generic skills, including languages, internet technology, interpersonal communication, quantitative and analytical skills and the ability to learn how to learn". However, as study of mathematics and statistics is not compulsory in the curriculum of senior secondary education, freshmen of sub-degree programmes are always having diverse mathematical backgrounds. Educators in Community Colleges in Hong Kong face significant challenges in helping students, particularly students with lower level of numeracy, to enhance their quantitative and analytical skills and to be numerically literate. Finding resources to explore multiple ways to assist students in strengthen their numeracy has thus, become one of the major tasks of the College to improve the quality of the graduates from AD/HD programmes.

The purpose of this study is to have a better understanding of college freshmen's mathematics/statistics background. Then, the relationship between college freshmen's mathematics/statistics background and their performance in studying the compulsory mathematics/statistics subject is investigated and presented in this paper. Finally, some additional support services are suggested to provide for students to improve their mathematical ability and ultimately enhance their learning in the college.

2. Hong Kong Publication Examination

The Hong Kong Examinations and Assessment Authority (HKEAA, 2014a) had administered the first Hong Kong Advanced Level Examination (HKALE) since 1980. With the implementation of the New Academic Structure (NAS), the HKEAA administered the final HKALE for school candidates in 2012 and the final HKALE for private candidates in 2013.

2. 1 Hong Kong Advanced Level and Examination

Syllabuses of HKALE subjects can be categorised into two types: Advanced Supplementary (AS) level and Advanced Level (AL). AS level subjects were taught in half the amount of periods required for AL subjects, but, they required the same level of intellectual rigour. The results of the HKALE were expressed in terms of six grades (i.e. A, B, C, D, E and F), of which grade A was the highest and F the lowest. Results below grade F were designated as unclassified (UNCL).

The following subjects related to mathematics and/or statistics are of interest:

- Applied Mathematics (AL)
- Applied Mathematics (AS)
- Mathematics and Statistics (AS)
- Pure Mathematics (AL)

2. 2 Hong Kong Certificate of Education Examination

The HKEAA (2014b) had administered the Hong Kong Certificate of Education Examination (HKCEE) since 1978. The HKCEE had been one of the most well established and recognised public examinations in Hong Kong. The HKCEE is normally taken by students at the end of their five-year secondary school education. With the implementation of the New Academic Structure (NAS) and Hong Kong Diploma of Secondary Education (HKDSE) Examination, the final HKCEE for school candidates and private candidates took place in 2010 and 2011, respectively. Except for the subjects of Chinese Language and English Language, the results of all other

subjects of the HKCEE were indicated by six grades (i.e. A, B, C, D, E and F), of which grade A was the highest and grade F was the lowest. Results below grade F were designated as unclassified (UNCL).

The following subjects related to mathematics and/or statistics are of interest:

- Additional Mathematics (HKCEE)
- Mathematics (HKCEE)

3. Post-Secondary Education in Hong Kong

Hong Kong provides multiple and flexible pathways for local students to pursue post-secondary education (Education Bureau, 2014). There are eight degree-awarding institutions funded by the University Grants Committee (UGC), which provide 15 000 first-year, first-degree places. As these institutions admit students at their own discretion, prospective students may apply through the Joint University Programmes Admission System (JUPAS). Apart from these places, some of the publicly-funded institutions, such as The Hong Kong Polytechnic University (PolyU) also provide a number of publicly-funded sub-degree programmes (i.e. programmes of full-time sub-degree, bachelor's degree and top-up degree programmes not covered by JUPAS) so as to provide more opportunities to young people access to post-secondary education. Prospective students who want to admit to any sub-degree programme have to fulfil either one of the following entry requirements:

i. Grade E in 5 HKCEE subjects, including English Language and Chinese Language; or Grade E in 3 HKCEE subjects plus level 2 or above in English and Chinese; and Grade E in 1 HKALE subject; or Grade E in 2 HKALE (AS-Level) subjects, which may include Use of English, and Chinese Language and Culture; OR
ii. Satisfactory completion of a one-year Pre-AD Programme offered by a recognised institution; OR
iii. The equivalents of the above requirements.

For those students who do not possess the above-mentioned qualifications, but have reached the age of 25 by 1 September in the admission year, they may apply as "mature" students. Mature candidates are expected to demonstrate proficiency in English to study for the programme to the satisfaction of the admissions panel of the institution.

3. 1 Category of Qualifications of the Freshmen Level

It is believed that students' qualifications are highly related to their learning effectiveness in the college. Thus, the qualifications of the freshmen are categorized into ten groups for analysis. These groups are listed as follows:

Category 0 – Students pass in 3 AL subjects and pass in Use of English (UE)
Category 1 – Students pass in 3 AL subjects but fail in UE
Category 2 – Students pass in 2 AL subjects and pass in UE
Category 3 – Students pass in 2 AL subjects but fail in UE
Category 4 – Students pass in 1 AL subject and pass in UE
Category 5 – Students pass in 1 AL subject but fail in UE
Category 6 – Students pass in 2 AS subjects and pass in UE
Category 7 – Students pass in 2 AS subjects but fail in UE
Category 8 – Students successfully completed Pre-AD Programmes
Category 9 – Students with other qualifications

3. 2 Hong Kong Community College (HKCC)

As one of the self-financed post-secondary institutions in Hong Kong, Hong Kong Community College (HKCC, 2014) is established in 2001 under the auspices of The Hong Kong Polytechnic University (PolyU). HKCC offers Associate Degree (AD) and Higher Diploma (HD) programmes spanning the domains of arts, science, social sciences, business, design and the specialised area of health care for senior secondary school leavers.

3. 3 Schemes, Programmes and Compulsory Maths/Stats Subjects

In HKCC, there are 6 major schemes, including 35 programmes. Three schemes are selected for studying. These selected schemes and programmes are summarized as follows together with the compulsory subject in mathematics/statistics that students required to study:

i. AD Scheme in Business

- Programmes included: Accounting and Finance (AF), Business Management (BM), China Business (CB), Global Business (GB), Hospitality Management (HM), Human Resources Management (HR), Information Systems & Knowledge Management (IK), Logistics & Supply Chain Management (LM), Marketing (MK), Tourism Management (TM) and No Stream (NS)
- Compulsory subjects: Quantitative Method for Business (Studying in Stage 1 Semester 1) And Business Statistics (Studying in Stage 2 Semester 2)

ii. AD Scheme in Applied Social Sciences

- Programmes included: Psychology (PSY), Sociology & Culture (SC), Social Policy & Administration (SPA), Social Welfare (SW) and No Stream (SSNS)
- Compulsory subject: Elementary Statistics (Studying in Stage 1 Semester 1)

iii. AD Scheme in Humanities and Communication

- Programmes included: Arts (AA), English for Business Communication (EBC), Bilingual Communication (BC) and Language & Culture (LC)
- Compulsory subject: Elementary Statistics (Studying in Stage 1 Semester 2)

3. 4 Entry Test

In order to better understand the numeracy of the freshmen, an entry test on numerate literacy was administrated to all stage-1 AD/HD students before the commencement of the first semester of their sub-degree studies in the academic year 2011/2012. There are twenty multiple-choice questions for each test. The test was divided into three main sections, namely, Elementary Algebra, Pre-Calculus, and Basic Statistics. Each covered some key concepts of mathematics and/or statistics that are fundamental but essential for students' studies in the college. The results of the test would help college lecturers to gauge students' mathematics competences, and hence to tailor the teaching for students' benefit.

3. 5 Subjects' Grading

After students completed the continuous assessment and examination of each subject, all subjects in HKCC will be graded on the basis of Criterion-Referenced Assessment (CRA). Grades will reflect the extent to which a student has attained the Intended Learning Outcomes. Grades are to be interpreted as follows in Table 1.

4. Data Analysis

A survey was carried out on freshmen in the College who need to learn a compulsory mathematics and/or statistics subjects in academic year 2011/2012. Information on students' mathematics and statistics background were also collected in the followings.

Table 1: Grading

Subject Grade	Grade Point (GP)	Short Description
A+	4.5	Exceptionally Outstanding
A	4.0	Outstanding
B+	3.5	Very Good
B	3.0	Good
C+	2.5	Wholly Satisfactory
C	2.0	Satisfactory
D+	1.5	Barely Satisfactory
D	1.0	Barely Adequate
F	0.0	Inadequate

"F" is a subject failure grade, whilst all others ("D" to "A+") are subject passing grades.

4. 1 Important Attributes

In Table 2, several important attributes are identified which may highly influence the freshmen's study on compulsory mathematics/statistics subject. These attributes are programmes that the freshmen studying in, public examination results particularly in various mathematics subjects, and the result of entry test. Quantitative data collected from the survey were then coded according to the following Table 2.

Table 2: Attributes and Coding

Attributes	Levels
Programme:	
AF, BM, CB, GB, HM, HR, IK, LM, MK, TM, NS, AA, EBC, BC, LC, PSY, SC, SPA, SW & SSNS	1 – Progrmame that student registered 0 – Else
Public Examination:	
Applied Mathematics (AL)	5 – Grade "A"
Applied Mathematics (AS)	4 – Grade "B"
Mathematics and Statistics (AS)	3 – Grade "C"
Pure Mathematics (AL)	2 – Grade "D"
Additional Mathematics (HKCEE)	1 – Grade "E"
Mathematics (HKCEE)	0 – Else
Result of Entry Test	0 – Lowest mark to 20 – Full mark

4. 2 Regression Analysis

Regression analysis by using SPSS statistical software was performed to calibrate the relationship between students' mathematics/statistics background and their performance in studying the compulsory mathematics/statistics subject in their AD study. A statistical measure – T test was used to investigate the significance of the estimated parameter of each attribute. In the following sections, the test results of the regression analysis are presented by different scheme.

4. 2. 1 Business Scheme

Students under the Business Scheme are required to study two compulsory general education subjects, namely Quantitative Method for Business and Business Statistics. Students are firstly required to study Quantitative Method for Business during stage one semester one. The main content of this subject cover financial mathematics, matrix algebra, decision sciences and linear programming. Students are then required to study Business Statistics during stage two semester two. After the regression analysis had been conducted, the estimated parameters for each attributes together with t-statistics are shown in Table 3.

It can be seen in Table 3 that there are significantly positive impact of the Entry Test on the students' performances in studying both compulsory subjects (i.e. 0.035 vs 0.036). Thus, students would perform better in both compulsory subjects if they got better results in the entry test. However, negative impact of the category on their performance in both compulsory subjects can be found significantly (i.e. -0.049 vs -0.062). According to section 3.1 - category of qualifications of the freshmen, freshmen would be classified into different category based on their overall performance in public examinations. The lower score of category that student has, the higher of his/her public examination results. In other word, students performed well in public examinations, they also performed well in both compulsory subjects.

It is interesting to note that students studied the subject Mathematics and Statistics in their senior secondary education may influence their performance in both compulsory subjects in AD study (0.078 vs 0.239). It can be explained that the main content of the subject Mathematics and Statistics covers elementary statistics such as descriptive statistics, simple probability theory and commonly used probability distributions. Thus, these contents are essential for both compulsory subjects, but the impact in the subject Business Statistics is more significant. (i.e. 0.239).

Table 3: Estimated Parameters – Business Scheme

Compulsory Subject	Quantitative Method for Business		Business Statistics	
	Estimated Parameter	t-statistic	Estimated Parameter	t-statistic
Explanatory Variables				
Constant	2.262	27.159	1.975	16.937
Entry Test	0.035	7.264	0.036	5.837
Category	-0.049	-5.881	-0.062	-5.660
Pure Maths (HKAL)	0.104	1.991	--	--
Applied Maths (HKAL)	--	--	--	--
Applied Maths (HKAS)	--	--	0.372	1.812
Maths and Stat (HKAS)	0.078	2.591	0.239	6.216
Additional Maths (HKCEE)	0.046	1.990	0.054	2.062
Maths (HKCEE)	0.143	5.948	0.132	4.175
Dummy Variables				
Business - AF	0.352	6.739	0.483	6.401
Business - NS	0.348	5.763	0.567	6.576
Business - MK	0.161	2.698	0.384	4.480
Business - HM	0.136	2.167	0.282	3.179
Business - HR	--	--	0.373	3.287
Business - BM	--	--	0.478	4.038

Business - LM	0.547	4.421	0.425	2.510
Business - GB	0.400	3.537	--	--
Model Summary				
Number of Data	1256		1256	
R-square	0.335		0.248	

However, student's performance in studying Pure Mathematics may only positively influence their study in the subject Quantitative Methods for Business, (i.e. 0.104) but not in the subject Business Statistics. It can be partially explained that if students built up a strong foundation in numeracy when they studied Pure Mathematics, they can then easily catch up the subject contents of Quantitative Methods for Business and get better results.

Similar to that of students studying the subject Applied Mathematics in their senior secondary education, student's performance in this subject may only influence their study in the subject Business Statistics but not in the subject Quantitative Methods for Business. It can be explained by the main content of this subject related to more advanced statistics topics including probability theory and probability distribution and statistics inference which also covered in the subject Applied Mathematics.

For the impact of various programmes, students studying in programmes of Logistics & Supply Chain Management (LM), Account and Finance (AF) and No Stream (NS) seemed to perform the best in both compulsory subjects compared with those studying other programmes.

4. 2. 2 Humanities and Social Sciences Schemes

Elementary statistics is a compulsory general education subject for students enrolled in Associate Degree Scheme in Applied Social Sciences and Associate Degree Scheme in Humanities and Communication programmes. The main content of this subject cover descriptive statistics, probability and inferential statistics. After the regression analysis by scheme had been conducted respectively, the estimated parameters for each attributes together with t-statistics are shown in Table 4.

Table 4: Estimated Parameters – Scheme in Applied Social Sciences and Scheme in Humanities and Communication

Compulsory Subject - Elementary Statistics	Humanities and Communication		Applied Social Sciences	
	Estimated Parameter	t-statistic	Estimated Parameter	t-statistic
Explanatory Variable				
Constant	1.888	13.490	1.686	11.900
Mark of Entry Test	0.035	3.881	0.051	6.105
Category	-0.057	-3.259	-0.075	-4.197
Pure Maths (HKAL)	--	--	--	--
Applied Maths (HKAL)	--	--	--	--
Applied Maths (HKAS)	--	--	--	--
Maths and Stat (HKAS)	0.403	4.318	0.269	3.771
Additional Maths (HKCEE)	0.112	2.458	0.135	3.024
Maths (HKCEE)	0.444	9.405	0.357	8.071
Dummy Variable				
Social Sciences - SC			0.241	2.644
Model Summary				

Number of Data	687	516
R-square	0.341	0.387

Similar results can be seen in Table 4 that there is a significantly positive impact of the Entry Test on the students' performances in both schemes (i.e. 0.035 vs 0.051). Thus, students would perform better in the compulsory subject if they got better results in the entry test. However, negative impact of the category on their performance in the compulsory subject can also be found significantly (i.e. -0.057 vs -0.075). As discussed in the previous section, the lower score of category that student has, the higher of his/her public examination results. If students performed well in public examinations, they also performed well in the compulsory subject.

Moreover, students studied the subject Mathematics and Statistics in their senior secondary education may positively heavily influence their performance in the compulsory subject (0.403 vs 0.269). It can be explained that the main content of the subject Mathematics and Statistics covers elementary statistics such as descriptive statistics, simple probability theory and commonly used probability distributions. Thus, students studying these contents may build up a good foundation in statistics that helps them studying the compulsory subject more easily. Similar to that of students studied the subjects Mathematics and Additional Mathematics in their secondary education, positively impacts are found in both two subjects as students build up good foundation of numerate literacy through studying these two subjects.

Conclusions

Results show that the relationship between students' mathematics/statistics background and their performance in studying the compulsory mathematics/statistics subject in the College is statistically significant. Students performed well in the public examinations generally perform well in the compulsory mathematics/statistics subject also. Nevertheless, analysis of data collected from students contributes to grow evidence that additional support from college to students, particularly those students with lower level of numeracy is of prime need. Moreover, the results give some insight to help college lecturers to explore multiple ways to assist students in strengthen their numeracy. Thus, it is hoped that with the better understanding of the students' mathematics and statistics background would contribute to students' learning effectiveness by improving their mathematical ability, their learning in the college and lifelong learning ultimately.

It is suggested that several additional support services are proposed for those students with lower level of numeracy who are required to learn the compulsory mathematics and/or statistics subjects in the college. In order to enhance students' learning effectiveness by improving their mathematical ability, analytical skills and numerical sense, two additional support services are proposed, namely Math Learning Centers and remedial courses for students with lower level of numeracy.

Math Learning Centers (Chan & Lee, 2012a) can be set up to provide students with an additional channel to seek help for mathematics-related problems that they encountered during their studies. The Math Learning Centers provide a relaxed, friendly and supportive atmosphere for students to learn mathematics. By working with other students and experienced staff, students will have a better understanding about the concepts covered in their mathematics and/or statistics classes.

Students with lower level of numeracy or limited mathematical backgrounds are suggested to attend the remedial courses (Chan & Lee, 2012b) which may review the fundamental, but essential mathematics concepts that have been covered in the secondary school curriculum. The remedial courses equip students with better foundations in mathematics. Upon the completion of the remedial courses, students will be able to cope with their learning of stage one mathematics and/or statistics subjects.

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Rerefrences

i. Chan, L. & Lee, J. Y. S., 2012a. *Learning Support in Mathematics and Statistics: Mathematics Learning Centre*. Proceedings of the 4th Annual International Conference on Education and New Learning Technologies, 2-4 July 2012, Spain, Paper no. 1207. (CD-ROM)

ii. Chan, L. & Lee, J. Y. S. (2012b). *Learning Support in Mathematics and Statistics: Remedial Courses*. Proceedings of the 5th International Conference of Education, Research and Innovation, 19-21 November 2012, Spain, Paper no. 420. (CD-ROM)

iii. Education Bureau. 2010. *Revised Common Descriptors for Associate Degree and Higher Diploma Programme*. Available at: http://www.ipass.gov.hk/pdf/Revised_Common_Descriptors_2010.pdf

iv. Education Bureau. 2014. *Post-Secondary Education: Overview*. Available at: http://www.edb.gov.hk/en/edu-system/postsecondary/index.html

v. Hawkes, T. & Savage, M., 2000. *Measuring the Mathematics Problem*. London: Engineering Council.

vi. Hong Kong Community College. 2014. *HKCC 2014 Guide to Enrolment*. Available at: http://www.hkcc-polyu.edu.hk/admission/

vii. Hong Kong Examinations and Assessment Authority. 2014a. *HKALE*. Available at: http://www.hkeaa.edu.hk/en/recognition/develop_hk_pub_exam/hkale/

viii. Hong Kong Examinations and Assessment Authority. 2014b. *HKCEE*. Available at: http://www.hkeaa.edu.hk/en/recognition/develop_hk_pub_exam/hkcee/

ix. Luk, H. S., 2005. The Gap between Secondary School and University Mathematics. *International Journal of Mathematical Education in Science and Technology*, 36(2-3), pp. 161-174.

x. MacGillvray, H., 2009. Learning Support and Students Studying Mathematics and Statistics. *International Journal of Mathematics Education in Science and Technology*, 40(4), pp. 455-472.

xi. Perkin, G., Pell, G. & Croft, T., 2007. The Mathematics Learning Support Centre at Loughborough University: Staff and Student Perceptions of Mathematical Difficulties. *Engineering Education,* 2(1), pp. 47 -58.

xii. Varsavsky, C., 2010. Chances of Success in and Engagement with Mathematics for Students who Enter University with a Weak Mathematics Background. *International Journal of Mathematical Education in Science and Technology*, 41(8), pp. 1037-1049.