

Structural Equation Model of Students' Competence in Mathematics among Filipino High School Students

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ABSTRACT

This study aimed to construct structural equation model of students' competence in mathematics through selected students profile variables. The structural model revealed interesting influence of the profile variables to the competency in mathematics. It can be conveyed that better mother's work status, higher educational level expected to complete, more confident and did not repeat kinder, have better competency in mathematics. The four variables that directly influenced the competence variables were also influenced with other profile variables such as family background. The family background and confidence level consistently had the highest total effect and indirect effect to the competence in mathematics. Hence, this model can serve as a guide in making programs in the classroom or curriculum in mathematics.

Keywords: confidence in mathematics, family background, mathematics achievement, mathematics performance, path analysis

The importance of mathematics beyond the four corners of the classroom is undeniable. Jain and Downson (2009) stated that the various function of mathematics particularly for mental and logical growth of students was basic for fundamental sciences and engineering courses. It was also mentioned that mathematics was given special attention in terms of educational system all over the world. Studies were conducted to improve mathematics education (Khine, Al-Mutawah & Afari, 2015) and to prepare individuals in the challenges and complexities in their lives particularly in making well-grounded decision by applying logical and mathematical reasoning (Bokar,

2013). Mathematics is applied in people's daily lives because of its functions in real life such as counting, computing sales, measuring dimensions and many more (Mariano, 2004 as cited by Valdez, 2016; Valdez & Guiab, 2015). Its importance was emphasized as early as primary school and it was described as a key component of the primary school curriculum (Zhao, Valcke, Desoete, & Verhaeghe, 2011).

Efforts were made to understand the factors that might influence students' achievement in mathematics. Regression analysis was used to determine predictors of mathematics achievement, performance or competence (Gurat & de Gracia, 2016; Valdez, 2016; Valdez & Guiab, 2015; Visser, Juan & Fezza, 2015; Maree, Aldous, Hattingh, Swanepoel & van der Linde, 2006; Geary, 2011; Zhao, Valcke, Desoete, & Verhaeghe, 2011). Factor analysis was also used in exploring factors that influence students to do mathematics (Dimakos, Tyrllis & Spyros, 2012). Also, correlation analysis involving direct and indirect factors was done (Güven & Cabakcor, 2013). On the other hand, some studies also used structural equation model in determining factors that might influence mathematics performance or achievements (Khine, Al-Mutawah & Afari, 2015; Leung, 2001; Yurt & Sunbul, 2014; Gokce, 2005). Structural Equation Modeling is a multivariate statistical model (Drton, 2016) that combines path, an extension of regression analysis and factor analysis (NC State University, Humanities and Social Sciences, as cited by Gokce, 2005). On the studies conducted using structural equation model, mathematics achievement was influenced significantly by affective factors (Khine, Al-Mutawah & Afari, 2015). It also mediates in mathematics teaching self-efficacy together with learning approaches (Leung, 2001). Other factors were mathematics self-efficacy, spatial ability, and problem solving and reasoning skills also affects mathematics achievement (Yurt & Sunbul, 2014). Socio economic status and teacher centered activities have also a positive impact on the mathematics and geometry achievement. Moreover, the more positive perception of success and interest towards mathematics and science are, the higher the scores in mathematics and geometry. Yet, student centered activities were negatively correlated with mathematics and geometry (Gokce, 2005).

The achievement of students in mathematics was measured through Programme for International Student Assessment (PISA). Some studies used the result obtained from the assessment to explore factors that might influence mathematics. İş (2003), as cited by Gokce (2005) modeled the data of Brazil, Japan and Norway in PISA to obtain the factors affecting mathematical literacy of 15 years old students. The study revealed that factors that influenced mathematical literacy were the students themselves, the families and the school. In addition, the attitude towards mathematics was found to be inversely correlated with mathematics literacy. The need to conduct studies that aimed to improve mathematics was revealed through the result in PISA. Philippines did not yet join this International Assessment. However, the result on mathematics achievement test as revealed in the Trends in International

Mathematics and Science Study (TIMSS) showed low achievement score of the Filipinos, 23rd out of 25 participating countries and 34th out of 38th countries in fourth grade math and eight grade mathematics respectively. (Gonzales, Guzman, Partelow, Pahlke, Jocelyn, Kastberg, & Williams, 2004).

Hence, with the limited studies on the use of structural equation model to determine factors that affects mathematics, factors explored that do not consider personal characteristics, other school-related experiences, family background and views and confidence on mathematics all together and the poor performance in mathematics, urged the need to conduct this study on structural equation model of students' competence in mathematics among Filipino high school students using the publicized PISA test.

RESEARCH METHOD

This study employed quantitative research design. The data in the study was from the data used by Gurat and de Gracia (2016) in exploring the predictors of students' competence in applying mathematics in real world problems. The data was obtained from fourth years students (grade 10) of selected high schools in Nueva Vizcaya. The instrument used in gathering was the publicized PISA Mathematics Test with Cronbach alpha coefficient of 0.875. The instrument underwent pilot testing before it was given to the student respondents. Communication letters were given to the authority of the schools. Upon approval, data gathering was scheduled. Students were given 45 minutes to 1 hour to answer the questionnaire and calculators were not allowed. All grade 10 students composing of 191 were enrolled and present during the conduct of the study in the recognized Engineering and Science Education Program (ESEP) and Philippine Science high school in Nueva Vizcaya were the respondents of the study answered the research instruments. Analysis of MOment Structures (AMOS) was used to construct structural equation model of students' competence in applying mathematics in real world problems. AMOS is an extension of the general linear model (GLM) that enables a researcher to test a set of regression equations simultaneously.

RESULTS

As gleaned in Figure 1, the Structural equation model of students' competence in applying mathematics in real world problems fits the model, $\chi^2(63)=79.213$, $p >0.05$. The variables that directly affect students' competency in applying math in real world problems are mother's work status, highest level expected to complete, level of confidence in math and repeated kinder. Skipping classes is the only variable that directly affects repeated kinder. Tardiness and view on math directly affect the students' level of confidence in the subject. Figure 1 shows the structural equation model of students' competence in mathematics.

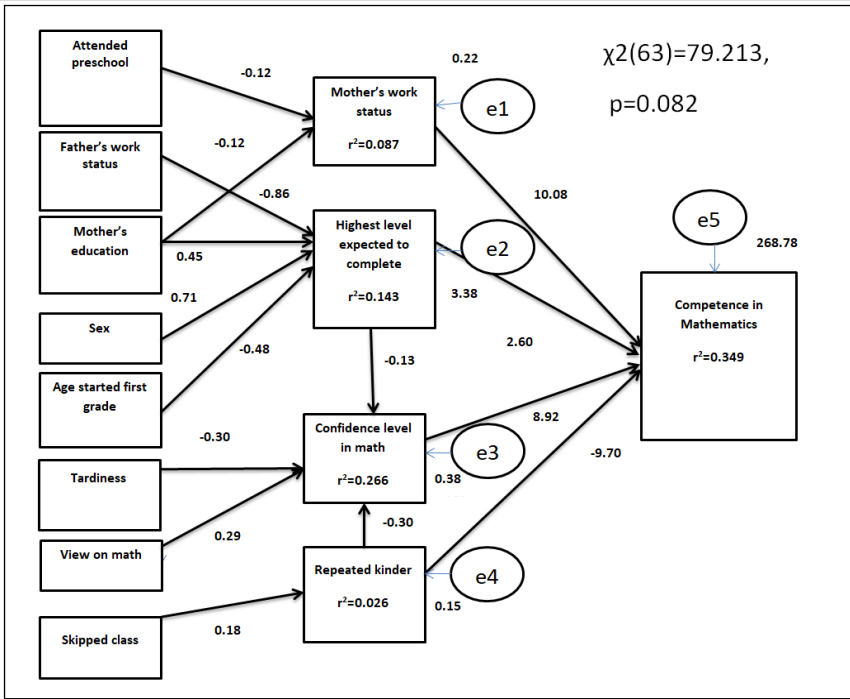


Figure 1. Structural equation model of students' competence in mathematics

Whereas, age started first grade, sex, mother's education and father's work status directly affect the highest expected level of completion. Mother's education and attendance to preschool directly affect mother's work status. Furthermore, variables such as highest level expected to complete and repeated kinder directly affect the level of confidence in mathematics. The figure also reveals that mother's work status, highest level expected to complete, confidence level in math, and repeated kinder have coefficient of determination (r^2) of 0.087, 0.143, 0.266, and 0.026 respectively. This indicates that 8.7%, 14.3%, 26.6% and 2.6% of the variances were accounted to mother's work status, highest level expected to complete, confidence level in math, and repeated kinder respectively.

These four variables were the identified predictors of competence in Mathematics in the study of Gurat and de Gracia (2016). Factors such as mother's education, father's or mother's work status or family background in general is supported by Egalite (2016) who identified factors such as family education, income, criminal activity and family structure that might influence students' achievement in general. Dimakos, Tyrllis and Spyros (2012) also reported that students' fathers and their mothers were among the factors that influence students to do in Mathematics. The influence of level of confidence

to mathematics and mathematics achievement is supported by Mohd, Mahmood, and Ismail (2011). However, Mettas, Karmiotis and Christoforou (2006) revealed the association of attitudes and achievement but disconfirmed the association of self-confidence or self-beliefs in achievement but this is in science.

The variables e1, e2, e3, e4 and e5 in the model are other possible variables that might influence the variables connected to it. Possible factor that might influence the mother's work status aside from the variables in the model is sense of obligation such as being there for the child and optimizing the child's development and growth. Another factor is negotiating the obstacles such as problems on child's care, father's lack of involvement to the child, and relatives and friends' lack of support for the mother toward securing employment (Youngblut, Brady, Brooten & Thomas, 2000). However, this is the case of a single mother.

Possible factors that might influence students' highest level expected to complete is socio economic status. This is supported by the study of Diemer and Blustein (2007) that career barriers were higher from poor, people of color, women and those who are disabled. Yet in the Philippine concept, possibility would only be true in terms of socio economic status and not for racial or ethnicity. The study of Ali, McWhirter and Chronister (2005) also supported this by revealing in their study that individuals from lower social class were less career-related self-efficacy in terms of vocational aspirations. Others factors are lack of guidance support and the lack of general college knowledge such as information about expectations in college and the application procedures (Temple, 2009).

Possible factors that might influence students' level of confidence in math are teachers' factor, self-efficacy and self-judgement (Marchis, 2011). Nonetheless, the identified teacher factors include teachers' attitude to mathematics, his/her confidence and his/her support to pupil influences attitudes towards mathematics in general and not only in confidence. Other factors are teachers' lack of student motivation and engagement in academic work as considered by Mata, Monteiro and Peixoto (2012) or teacher factor as reported by Dimakos, Tyrllis and Spyros (2012). Possible factor that influence an individual to repeat kinder is parents' decision. Some of the parents' reasons are the child's confidence, self-esteem, readiness and maturity to go to first grade (Circle-of-Moms-editors, 2011). Possible characteristics of the students who repeated kinder are the significantly worse performance compared with late entry in kinder and problem in the concentration of the individual inside the class (National Center for Education Statistics, 2002).

The Table 1 displays the unstandardized regression coefficients. The unstandardized coefficients and the associated test statistics appear in the Table. Each unstandardized regression coefficient represents the amount of change in the dependent or mediating variable for each one unit change in the variable predicting it. This means that for every one unit increase in skipped whole day variable, the repeated kinder increased by 0.18 and for every unit

increase in repeated kinder, the competence score in mathematics is reduced by 9.70. This also means that the students who tend to skip class for whole day also the same student that repeated kinder and those who students who repeated kinder have lower competency in mathematics. This is supported by National Center for Educational Statistics (2012) that students who repeated kinder tend to have significantly worse performance.

Table 1. Regression Weights

Variables			Estimate	S.E.	C.R.	P
Repeated kinder	<---	Skipped whole day	0.18	0.079	2.260	.024**
Competence score	<---	Repeated kinder	-9.70	3.064	-3.166	.002**
Highest level expected	<---	Age started first grade	-0.48	0.230	-2.102	.036*
Highest level expected	<---	Father's work status	-0.86	0.291	-2.935	.003**
Highest level expected	<---	Sex	0.71	0.284	2.491	.013**
Highest level expected	<---	Mother's education	0.45	0.154	2.932	.003**
Competence score	<---	Highest level expected	2.60	0.653	3.981	.000**
Mother's work status	<---	Mother's education	0.12	0.040	3.015	.003**
Mother's work status	<---	Attended preschool	0.12	0.048	2.422	.015**
Competence score	<---	Mother's work status	10.08	2.450	4.113	.000**
Confidence level in math	<---	View on math	0.29	0.074	3.943	.000**
Confidence level in math	<---	Highest level expected	0.13	0.023	5.873	.000**
Confidence level in math	<---	Tardiness	-0.30	0.090	-3.338	.000**
Confidence level in math	<---	Repeated kinder	-0.30	0.114	-2.633	.008**
Competence score	<---	Confidence level in math	8.92	1.806	4.941	.000**

Legend: *significant at 0.05 level **significant at 0.01 level
 Note: regressions coefficient of e1 to e5 are significant

The result also shows that for every single unit increase in age started first grade, and father's work status, the highest level expected to complete is reduced by 0.48 and 0.86 respectively. Every one unit increase in variables sex and mother's education, the highest level to complete is also increased by 0.71 and 0.45 respectively. On the other hand, the single unit increase in highest level expected to complete can increase the competence score by 2.60. This indicates that the student who enrolled in first grade at right age, better father's work status, lower educational attainment of the mother and is female student, the lower the educational level the student expects to finish. Yet, the higher the level of educational attainment the student expects to finish, the student has better competency score in math. Mother work's status can also be increased by 0.12 for every unit increase in mother's education and the child attended preschool. Every single unit increase in mother work's status can increase competence score by 10.08. This points to higher education of mother of the child that was sent to preschool, the better the mother's work status and the child has higher competency in math. This is supported by Egalite (2016) that family background can influence achievement of the student. Also, socio economic status influences students' highest educational level he/she expected to complete (Diemer and Blustein, 2007).

Students' view on math and highest educational level expected to complete influence the confidence level in mathematics by 0.29 and 0.13 respectively. Variables such as tardiness and repeated increase can influence confidence level in math by -0.30. The confidence level in math can increase competence score by 8.92. This reveals that if the student has more positive view in math and he/she has higher educational level expected to complete, the more confident the student. However, the more tardy the student and that he/she repeated kinder, the lesser the student's confidence in math. Students who are more confident have higher competency level in math. Influence of confidence level is supported by Mohd, Mahmood, and Ismail (2011).

To see the total effects of each variable to the competence in mathematics, Table 2 displays the total effects to the competence in mathematics.

Table 2. Total Effects to Competence in Mathematics

Variables	Beta Weights
Repeated kinder	-12.37
Skipped whole day	-2.21
Father's work status	-0.34
Attended preschool	1.164
Age started 1 st grade	1.84
View on math	2.62
Sex	2.68
Tardiness	2.69
Mother's education	2.93
Highest level expected to complete	3.79
Confidence level in math	8.92
Mother's work status	10.08

As gleaned in Table 2, the highest negative effect is repeated kinder (-12.37) and the two highest positive effects are confidence level in mathematics (8.92) and mother's work status (10.08).

Table 3. Indirect Effect to Level of Confidence and Competence Score in Mathematics

	A	B	C	D	E	F	G	H	I	J
Confidence level in math	-0.11	0.06	0.09	-0.07	-0.05	-	-	-	-	-
Competence score	3.24	2.93	2.68	1.84	2.21	1.19	2.69	2.62	1.16	2.67

Legend: A(Father's work status), B(Mother's education), C(Sex), D(Age started 1st grade), E(Skipped whole day), F(Highest level expected to complete), G(Tardiness), H(View on math), I(Attended preschool), J(Repeated kinder)

As shown in Table 3, father's work status, mother's education, sex, age started first grade, and skipped whole day class has indirect effects on confidence in mathematics. The father's work status has the highest indirect effect. The indirect effects of the variables to the competence score range from 1.16 to 2.93 positive direct effects and 1.84 to 3.24 negative indirect effects. Consistent with the indirect effect to confidence level in math, father's work status has the highest negative effect to the competence score and mother's education has the highest positive indirect effect on the competence score.

CONCLUSIONS

Findings revealed that structural model of students' competence in applying mathematics to real-world problems revealed the interesting influence of the profile variables to the competency in mathematics. The structural equation model conveys that:

- Students who have better mother's work status, the higher educational level expected to complete, more confident, and did not repeat kinder have higher competency in mathematics.
- Students who skipped class for the whole day and have repeated kinder have lower competency in mathematics.
- Students who enrolled in first grade at the right age (7 years old), have better father's work status, lower educational attainment of the mother and female, have lower educational level expected to complete. Yet, the higher level of educational attainment the students expected to finish, they have better competency score in mathematics.
- Students who have the mother with higher educational level and better work status, and the students were sent to preschool, the higher the students' competency in math.
- Students who have the more positive view in math and higher educational level expected to complete, are more confident students. However, the tardier the students are and that they repeated kinder, the lesser their confidence in mathematics. Students who are more confident have higher competency level in math
- The family background such as mother's work status, mother's education, and father's work status was consistently the highest in total effect and indirect effect as well as the confidence in mathematics.

RECOMMENDATIONS

Based on the findings of this study, the following are recommended:

- To use this model as a guide in making programs or interventions in the classroom to develop students' competency in mathematics, the

variables with highest total effects and indirect effects may be considered.

- To use the model as a basis for reviewing the curriculum in mathematics. The relationships from the model can be basis for determining factors that might affect the students' understanding in mathematics and can be guide for some adjustment or revisions in mathematics curriculum.
- To conduct a similar study that will involve larger sample size of students.
- To explore other possible factors that influence mother's work status, highest educational level the students expected to complete, the confidence level in mathematics and repeated kinder. Other factors that influence competency in mathematics and not yet in this study can also be explored.

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