Gender differences in mathematics performance: Walberg's educational productivity model and the NELS: 88 Database

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Abstract
A disparity in advanced mathematics achievement and upper-level mathematics course-taking patterns exists that contributes to fewer females than males choosing professions in math, science, and technology fields. This study used a secondary analysis of the National Educational Longitudinal Study of the 1988 database (NELS: 88) and Walberg's Educational Productivity Model to determine whether the Productivity Factors in the model operated differently for males and females. Productivity Factors from the eighth grade NELS: 88 database were used to model the 12th grade outcomes related to achievement testing, coursework, and attitude toward mathematics. Multiple and logistic regression analyses were run to examine the relationship of the Productivity Factors with the mathematics achievement and attitude outcomes. Findings indicate that a number of the Productivity Factors are significantly related to these outcomes and appear to operate differently for males and females.
Keywords: Mathematics education; Differences in mathematics performance; Walberg's Educational Productivity Model.

Diferenças de Gênero em desempenho de matemática: Modelo de produtividade educacional de Walberg e base de dados de NELS:88

Resumo
A existência de uma disparidade em desempenho de matemática avançada e na participação em cursos de matemática de alto nível contribuem para que menos mulheres do que homens escolham suas profissões nas áreas de matemática, ciência e tecnologia. Este estudo utilizou uma análise secundária do Estudo Longitudinal Educacional Nacional do banco de dados de 1988 (NELS: 88) e o Modelo de Produtividade Educacional de Walberg para determinar se os Fatores de Produtividade no modelo operavam diferentemente para homens e mulheres. Os fatores de produtividade de oitava série do banco de dados de NELS: 88 foram usados para modelar os resultados do 12º ano relativos ao teste de realização, do trabalho de curso, e a atitude em relação à matemática. Análises de regressão múltipla e logística foram executadas para examinar a relação dos Fatores de Produtividade com o desempenho da matemática e os resultados de atitude. Os resultados indicam que um número de Fatores de Produtividade são significativamente relacionados a esses resultados e parecem operar de maneira diferente para homens e mulheres.
Palavras-chave: Modelo de Produtividade Educacional de Walberg; NELS: 88; Matemática; Gênero.

While gender differences in mathematics achievement and attitudes overall have been declining in the past three decades, there still exists a disparity in advanced mathematics achievement and upper-level mathematics course-taking that contributes to fewer females than males choosing professions in math, science, and technology fields. Although 21th century females have completed high school and attended college in increasing numbers, they have consistently expressed less interest in learning about mathematics and science careers, have had lower aspirations in these fields, and have had less confidence that there are mathematics or science jobs that they can learn to do (Halpern, Aronson, Reimer, Simpkins, Stat, & Wentzel, 2007; Kahle & Lakes, 1983). Even high-achieving adolescent girls who have completed advanced coursework in mathematics and science do not choose to pursue careers or college studies in mathematics and science in numbers proportional to their male counterparts (Dick & Rallis, 1991; Watt, Eccles, & Durik, 2006). Furthermore, Dick and Rallis (1991) report that even when high school females are performing at higher academic levels than their male counterparts, they continue to express less interest in mathematics and science careers.

These career decisions have led to an underrepresentation of women in mathematics (referred to as "math" in what follows) and related fields of science and engineering, which in turn contributes to the significant gap in economic earning ability between males and females (National Center for Education Statistics, 2008). Kim (2000) noted that

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women hold the majority, 59% of low wage jobs. Although increasing numbers of females are enrolling in advanced business, law, medicine, and science coursework, they are still underrepresented in these professions.

While the recent decline in the labor pool that supplies the nation with scientists and engineers has brought renewed attention to encouraging both males and females to pursue careers in math and science, equity advocates have specifically focused on issues that concern women's participation in the scientific labor force (Fuller, 1997). While females comprise 47% of the national work force, they represent only 39% of those in math, science, and technology fields (United States Government Accountability Office, 2007).

Research has shown that although both boys and girls acknowledge multiple career options for females, their personal aspirations tend to be sex-stereotyped (Berryman 1993; Pettit, 1995; Watt, Eccles, & Durik, 2006). While girls feel more capable in doctor/veterinary jobs they feel less able to succeed in more purely physical science-related jobs. Even with comparable achievement records, ninth grade girls like mathematics less than boys and are less likely to indicate interest in a mathematically-related career.

Data from the 2003 Third International Mathematics and Science Study (TIMSS) indicated that boys continued to outperform girls in mathematics. While scores for both increased, the gain from 1995 scores was the same, 12 points, with the boys' average score going from 495 to 507 and girls' average score going from 490 to 502 (National Center for Education Statistics, 2005). In addition, there is a continued, increasing discrepancy between the scores of high achieving (above the 75th percentile) males and females and a continuing discrepancy in the mathematics coursetaking patterns of males and females (Friedman, 1989; National Center for Education Statistics, 1998).

Scores on the Scholastic Aptitude Test (SAT) reported by the College Board in 2007, confirmed a continuing gender difference in achievement among top performing students. Although 57% of the SAT-takers were girls who graduated among the top 10 percent of their class in 2007, the girls' average score on the math portion of the SAT was 499 points, compared with 533 for boys, out of a possible 800 (College Board, 2007). In addition to this high-end achievement and coursework disparity, many unexplained gender differences also persist with respect to motivation, perceived usefulness of mathematics, and career aspirations (Fuller, 1997).

Using data from tests administered to students before they start to diverge in terms of number and level of mathematical courses taken reveals that courses in mathematics alone can not explain the difference in test scores (Wilder & Powell, 1989). Other factors then, including home and classroom environment, peer influences, parental educational level, and aspirations, need to be considered to understand achievement differences in mathematics.

The Present Study

The purpose of this study is to investigate gender differences in mathematics achievement and attitude, looking at the effects of student aptitude, instruction, and the psychological environment on those outcome variables. Specifically, this work will examine the effect of the Educational Productivity Factors upon the mathematics achievement and attitudes of males and females.

Walberg (1984, 1992) theorizes that educational outcomes can be analyzed from a business or economic productivity model, and that combinations of these factors influence what he calls educational productivity. His theoretical framework is an augmentation of previous multivariate models, such as Carroll and Spearritt's (1967) Model of Academic Learning and Bloom's (1976) Model of Mastery Learning. The assumption of this model is that academic learning is based upon affective, behavioral, and cognitive activity that is primarily a function of individual ability, yet is strongly affected by environmental and instructional variables as well.

Walberg's model encompasses nine factors which fall into three categories: student aptitude, instruction, and psychological environment. Student aptitude includes three items: (a) ability or prior achievement, (b) development, and (c) motivation, or self-concept. Instruction includes two items: (a) the amount of time students engage in learning, and (b) the quality of the instructional experience. The environment factors encompass four items: (a) the home, (b) the classroom social group, (c) the peer group outside the school, and (d) use of out-of-school time. These nine factors have proven to be potent, consistent, and generalizable since they are grounded upon a synthesis of over 3,000 studies of the variables that impact school learning (Walberg, 1984).

While several of the independent variables in Walberg's (1984, 1992) model are fixed (gender, SES, parent educational level), others form part of what he terms the "alterable curriculum." He states that in order to improve academic achievement, the alterable factors of the Educational Productivity

Model need to be identified and addressed.

Method: Data Source

This study utilized the National Educational Longitudinal Study of 1988 (NELS:88) database in testing Walberg's Educational Productivity Model and determining whether it applies similarly for both males and females to explain differences in mathematics achievement and attitude. NELS:88 was an on-going data collection project sponsored by the National Center for Education Statistics (NCES) of the U. S. Department of Education. Its goal was to collect comprehensive information at specified intervals on the family, school, and community experiences of a national cohort of 1988 eighth-graders as they progressed through school and entered the workforce. The longitudinal design of NELS:88 permitted the examination of change in young people's lives and the role of schools, teachers, community, and family in promoting growth and positive outcomes (NCES, 1998). The final data collection for NELS:88 took place in 2000, as the initial cohort of 1988 eighth graders were eight years post-high school.

Explanation of Sample Size

The original NELS:88 database contains information on 24,599 eighth grade students. The first step in the selection of cases to be used in the present study was to identify those variables in the NELS:88 database that would match as closely as possible the factors in Walberg's Educational Productivity model. From these variables, cases were selected which contained complete data in the following areas: the eighth grade student survey, eighth grade student achievement test, parent survey, mathematics teacher survey, school administrator survey, 12th grade student survey, 12th grade student achievement test, and high school transcript. While some information on drop-outs is available, few drop-outs had information on the 12th grade outcome measures for achievement and attitude. Since drop-outs as a group did not have a complete data set, they are not included in the present study.

The first limiting factor proved to be data from the eighth grade math teacher. Since the eighth grade population of over 24,000 students was initially divided into two segments, with either a math or science teacher surveyed for each segment, the sample size was reduced to 11,414 cases, due to non-response from some participating teachers. When considering the factors from student, parent, and school, further reduction in sample size occurred because of incomplete sets of data. The reduction was from 11,414 cases to 5,919 cases. Missing data appeared to be randomly scattered across categories of outcome and predictor variables, so no systematic deletion of cases was evident.

Further reductions were made as only those cases with complete sets of data for the dependent variables and an NCES assigned panel weight were selected for each model. After selecting for complete sets of the above independent variables, the dependent variable, and the correct panel weight, the first achievement outcome, 12th grade achievement test scores, contained a sample of 3,465 cases. The second achievement outcome, math coursework completed ("pipeline" data), had a total of 3,052 cases, and the final outcome, mathematics attitude, contained 3,285 cases.

Finally, in order to provide a sample for cross-validation, each of the three outcome models described above was then randomly split into 70% - 30% sub-groups. The regression models are based on the 70% sample. Approximately 30% of the sample is being retained for a future, follow-up study which will determine how well the results can be replicated.

Computer Analysis Program

The data was originally organized and evaluated using the Statistical Package for Social Sciences (SPSS) data analysis program. The main analyses, however, required the use of more sophisticated computer software, which would take into account the complex survey design of the NELS: 88 study. Although a statistical accommodation is provided by the NCES to calculate the design effect and correct standard error using SPSS, a more precise statistical analysis is available through sophisticated computer programs like Sudaan or WestVarPC. A statistical consulting group from the University of Illinois, Chicago was hired to run the data using Sudaan. Their statistician provided details on how to set up the separate analysis groups, organize the data, and transmit the files in a SAS-readable format which could be run in Sudaan.

An alpha level of .05 was used for all statistical tests. Because running the analyses in Sudaan accounts for the complex sampling design, and because cases must be weighted given the method of sample selection employed, the actual number of cases residing in the file differs from the effective sample sizes used in the analyses. The APA-style numerical summaries of each result report the actual number of cases, yet the statistical significance is based on the effective sample size. In addition, note that the sample sizes used result in very "powerful" tests which, in some instances, may result in finding statistically significant results that do not necessarily reflect meaningful differences.

Independent Variables

For this study, the independent variables included eight of the nine Educational Productivity Factors. These were: Student Aptitude, Motivation, Quantity of Instruction, Quality of Instruction, Home Environment, Classroom Environment, Peer Influences, and Television Viewing Time. The remaining Productivity Factor, Development, was omitted from the present study, because the students were all of the same grade level, so they were nearly homogeneous with respect to age. An additional independent variable was also included in this study to control for possible extraneous variation. The variable, taken from the eighth grade data, was School Socio-Economic Status (SES).

The eight factors from Walberg's Educational Productivity Model were represented by variables on the NELS:88 database that corresponded most closely with Walberg's original theoretical framework. The first factor, Student Aptitude, was measured by Prior Mathematics Achievement which came from the Item Response Theory estimated number right on the cognitive test of mathematics given in the base year of NELS:88. In order to facilitate comparisons between the base year math test and the second follow-up math test, Item Response Theory (IRT) scoring was employed to calculate the scores. The overlapping items on the 8^{th} and 12^{th} grade math achievement tests made it possible to use IRT scoring to develop scores that were on the same scale, which could be compared to measure gains over time (NCES, 1998).

The second factor, Development, did not vary in the present study and was not used. The third factor, Motivation, was separated into three sub-categories: Expectancy for Success, Locus of Control, and Usefulness of Mathematics. This separation was based on research linking these factors with motivation and academic achievement (Reyes & Stanic, 1985). Expectancy for Success was measured by an item from the base year student survey: "As things stand now, how far in school do you think you will get?"

The second sub-category of motivation, Locus of Control, came from a single composite variable which was created by the National Educational Longitudinal Survey from specific questions on the eighth grade student survey: "I don't have enough control over the direction my life is taking," "In my life, good luck is more important than hard work for success," "Every time I try to get ahead, something or somebody stops me," "My plans hardly ever work out, so planning only makes me unhappy," "When I make plans, I am almost certain I can make them work," and "Chance and luck are very important for what happens in my life." A composite score was created by standardizing items separately to a mean of zero and standard deviation of 1 and all non-missing components were averaged.

The final sub-category of motivation, Usefulness of Mathematics, was the eighth grade student's perception of the usefulness of mathematics in his/her future. A number of researchers, including Pedersen, Bleyer, and Elmore (1985), noted that this has been linked to mathematics achievement and course-taking patterns.

The fourth factor, Quantity of Instruction, was measured by an item from the base year teacher survey: "Approximately how many hours per week does this class meet regularly (exclude lab periods)?" This was based upon research which indicates that math achievement test outcomes are correlated to time spent in mathematics coursework in junior high and high school (Reyes & Stanic, 1985).

Quality of Instruction, the fifth factor, was measured by two items on the base year mathematics teacher survey: "How much emphasis do you give to problem solving?" and "How prepared do you feel to teach this course?" Fraser, Walberg, Welch, and Hattie (1987) found that the quality of instructional methods has an effect on mathematics achievement and attitude outcomes. Stevenson (1992) reported that students' mathematics achievement is enhanced by the teacher's emphasis on problem-solving activities. In addition, content knowledge and teacher preparation in mathematics are critical to the preparation and delivery of effective mathematics instruction and are positively related to mathematics achievement (Leinhardt, 1986; Mandeville & Liu, 1997).

The sixth factor, Home Environment, was measured using a number of variables from the base year student survey concerning home conditions and parental involvement in the student's educational experience. The indicators of home conditions were parental education level and family income. Parental involvement indices were: parent-student discussions of school related issues, parent-student discussions about future school-related plans, and what level of education the parent hoped the child would attain. Peng and Lee (1993) and Wilson-Relyea (1997) report a relationship between parental involvement in and discussions concerning school activities and students' mathematics achievement. In addition, research by Ibe (1994) notes a relationship between the educational aspirations for the child of the more highly educated parent and the subsequent student educational attainment.

The seventh factor, Classroom Environment, was measured by the student response to the base year survey questions: "I look forward to going to math class" and "I am afraid to ask questions in math class." The eighth factor, Peer Influence, was measured by the student response to the base year survey questions: "How often have you talked to friends or relatives your own age about planning your high school program?" and "Do you think other students in your classes see you as a good student?" The ninth and last factor in Walberg's Educational Productivity Model, television viewing time, was measured by the student response to the two base year survey questions: "How much time do you watch television on weekdays?" and "How much time do you spend watching television on weekends?"

An additional factor that was considered as a possible confounding variable was the base year School Socio-Economic Status. This was measured by the percent of students enrolled in the free or reduced-price lunch program. As work by Reyes and Stanic (1985) indicates, the SES of the school that a student attends is related to achievement and attitudinal outcomes. This variable, SES, was utilized to rule out the effect of school SES on the student outcomes.

Dependent Variables

The dependent variables used in the present study was mathematics achievement and attitude towards mathematics. Mathematics achievement was assessed in two ways: performance on a 12th grade math proficiency exam (Achievement Test); and highest level of mathematics coursework completed in high school, taken from the high school transcript (Achievement Coursework). The coursework data were coded as an intensity ranking (low to high, 1 - 8) of the actual level of math courses completed in high school. Level 1 indicated no mathematics classes taken at all, while level 8 referred to work in calculus or beyond.

The second outcome, students' attitudes toward mathematics, was a variable constructed from two questions on the 12th grade student survey. The two questions used to create the attitude outcome variable were asked of twelfth grade students either enrolled in a math class ("Is interest in math one of the reasons for taking this class?") or not taking a math class in their senior year ("Is the reason you are not taking a class because you are not interested in math?"). The first variable answers were on a Likert scale from 0 – 5, indicating agreement with the statement, "Is interest in math one of the reasons for taking this class?" The two lowest answers on the scale, "Not at all" and "Very little," were recoded as negative responses and given a value of 0. The next four answers, from "Somewhat" through "Agree strongly," were recoded as positive responses and given a value of 1. The answer to the question asked of 12th graders not currently enrolled in math, "Is the reason you are not taking math because you are not interested in math?" was a simple "Yes" or "No." These were recoded to correspond to the scale on the first question because a "No" to this statement would actually indicate interest in math. The recoded responses were then given a value of "0" or "1" to match the answers on the first question. These two subsets of data were then combined into a single variable representing the attitude outcome.

The use of an existing database (NELS:88) determined which of the potential variables were available for inclusion, and limited the scope of information that was used to fit the Educational Productivity Model by Walberg. However, unlike previous longitudinal studies, interviews from the parents, in addition to those from the students, were included in this database. This allowed for the estimation of both the sociological and psychological constructs in this model. The time frame of this database, from 8th to 12th grade, 1988-1992, was especially important because contemporaneous research showed that girls, more than boys, began to falter either academically in mathematics or in their mathematics self-concept during the junior high years and continued this decline throughout high school (Fennema & Sherman, 1978; Sherman, 1980a; Stipek & Gralinski, 1991; Wilson-Relyea, 1997).

Table 1

Description of variables in the model

Variable	Description
Main Predictor of Interest	
Gender	Male or Female
Control Variable	
School Socio-Economic Status	Eighth grade school report of socio-economic level of the school, based on percent free or reduced cost lunch.
Walberg's Factors	
Prior Mathematics	Eighth grade mathematics proficiency test
Motivation	
Expectancy for Success	Eighth grade student's educational goal.
Usefulness of Mathematics	Eighth grade student's report of usefulness of mathematics
Locus of Control	Eighth grade student's composite locus of control score
Quantity of Instruction	Eighth grade math teacher report of class meeting time per week.
Quality of Instruction	Eighth grade math teacher report of preparedness to teach class
	Eighth grade math teacher report of problem solv. emphasis
Home Environment	
Parental Support	Eighth grade student report of discussions about school programs, school activities, and things studied in class with parents
Parental H. S. School Plan Discussions	Eighth grade student report of discussions with mother and father about planning high school program
Parental Aspirations	Eighth grade student report of mother and father's educational aspirations for the student
Parental Education	Eighth grade parent report of parental educational levels
Family Income	Eighth grade parent report of family income
Classroom Environment	Eighth grade student's feeling about attending class.
	Eight grade student report of willingness to ask questions in math class.
Peer Influences	Eighth grade student report of discussions with peers about educational plans
	Eighth grade student report of peer's perception of student
Television Viewing Time	Eighth grade student report of leisure-time t.v. viewing
Outcomes	
Achievement Test	Twelfth grade math proficiency test
Achievement Coursework	Math course work from 12th grade transcript
Attitude	Twelfth grade student report of current interest in math

From the measures available in the NELS:88 database, items were selected that appeared to capture the Productivity Factor concepts best. For some Productivity Factors, multiple indicators were available, however in an attempt to build a parsimonious model, potential indicators within a set representing each Productivity Factor were compared through descriptive statistical analyses. Specifically, the correlation of each indicator with each of the three main outcomes was calculated, and further consideration was not given to those indicators which failed to correlate at least 0.15 with one or more outcomes. Exceptions were made to this general rule in cases where there was only one indicator for the Productivity Factor. To reasonably limit the number of indicators used for the Productivity Model as a whole, conceptually related indicators were formed into composites. Further justification for this decision relates to issues of multi-collinearity. It should be noted that the main purpose of this study was not to test Walberg's theory, but to get the best representation of his model from the indicators available in this database so as to determine whether the Productivity Factors can account for gender differences in the outcomes.

Analyses

For the two outcomes involving a continuous variable (overall math achievement testing and coursework), hierarchical multiple regression was used. For cases involving a dichotomous outcome, mathematics achievement (as indicated by being in the top testing quartile and in advanced, levels 6 – 8, coursework) and mathematics attitude, hierarchical logistic regression analyses were employed.

The hypothesis examining gender differences in the influences of the Productivity Factors was tested by looking at the standardized regression coefficients of the Productivity Factors with the female subsample alone, the standardized regression coefficients of the Productivity Factors with the male subsample alone, and the standardized regression coefficients for the Productivity Factor terms representing interactions with gender.

Separate hierarchical regressions were run for (a) males, (b) females, and (c) cross-product (i.e., between gender and each Productivity Factor) interaction terms. Both the models for males and females included the intercept term, the School SES covariate, and the set of 18 Productivity Factors. The cross-product model included the intercept term, the main effect for male gender, the School SES covariate, the set of 18 cross-product terms formed by multiplying an indicator for male gender with each of the 18 Productivity Factors, and a similar set of 18 cross-product terms formed by using an indicator for female gender. For each of the 18 Productivity Factors, a difference contrast was computed on the corresponding male- and female-cross product terms to examine gender differences. The standardized regression coefficients of the Productivity Factors for females are presented in Table 2, while the standardized regression coefficients of the Productivity Factors for males are in Table 3. Standardized regression coefficients representing gender differences in the Productivity Factors and their level of significance are presented in Table 4.

Table 2

Standardized Regression Coefficients of Female Productivity Factor Cross-Products and Their Level of Significance

Cross-products of Productivity Factors by Female Gender	Math IRT Achieve. Test Continuous	Math IRT Achieve. Test Top Quartile	Math Achieve. Coursework Levels 1 - 8	Math Achieve. Coursework Levels 6-8	Math Attitude
Prior Math Achiev.	** 0.91	** 0.37	** 0.11	** 0.18	** 0.04
Expectancy for Success	* 0.46	0.09	** 0.17	** 0.46	* -0.24
Locus of Control	0.15	0.03	** 0.30	** 0.75	-0.21
Usefulness of Math	* -0.54	* -0.50	0.12	0.02	** 0.31
Class time per wk.	** -0.61	* -0.35	0.04	-0.22	-0.02
Emphasis on Problem Solving	-0.30	-0.32	0.04	0.22	-0.23
Teacher preparedness	-0.30	-0.12	-0.02	-0.04	0.11
Parental Support	0.10	-0.30	-0.10	-0.45	-0.46
Parent talks about high school plans	** -1.04	-0.37	* -0.19	* -0.46	* 0.41
Parental aspirations	* 0.52	0.31	0.04	-0.01	0.10
Parent level of educ.	* 0.48	0.22	** 0.14	** 0.39	0.02
Family income	* 0.15	-0.03	0.02	0.03	0.01
Student feelings about math class	** 0.70	0.00	** 0.011	** 0.38	** 0.37
Student willingness to ask questions in class	0.09	0.28	0.02	0.11	0.10
Student discussion with peers	* -0.63	* -0.43	0.08	0.27	-0.24
Peer perception of student	** -1.15	** -0.91	* -0.16	-0.24	** -0.35
Weekday t.v. viewing	-0.03	-0.17	* -0.07	** -0.27	-0.06
Weekend t.v. viewing	0.20	* 0.30	** 0.09	** 0.21	0.07

Note: A positive Beta coefficient is associated with a higher (more positive) outcome for females.

* = significant at the $p < 0.05$ level

** = significant at the $p < 0.01$ level

Table 3

Standardized Regression Coefficients of Male Productivity Factor Cross-Products and Their Level of Significance

Cross-products of Productivity Factors by Male Gender	Math IRT Achieve. Test Continuous	Math IRT Achieve. Test Top Quartile	Math Achieve. Coursework Levels 1 - 8	Math Achieve. Coursework Levels 6-8	Math Attitude
Prior Math Achiev.	** 0.91	** 0.42	** 0.11	** 0.20	** 0.04
Expectancy for Success	** 0.56	-0.10	** 0.26	** 0.42	-0.15
Locus of Control	-0.04	-0.21	0.06	-0.14	0.03
Usefulness of Math	0.14	0.13	0.07	0.15	0.19
Class time per wk.	-0.24	-0.08	-0.07	-0.27	0.02
Emphasis on Problem Solving	-0.59	-0.39	-0.01	-0.12	-0.05
Teacher preparedness	0.36	** 0.86	-0.09	-0.11	-0.28
Parental Support	-0.13	-0.40	-0.01	0.03	-0.46
Parent talks about high school plans	-0.21	-0.01	-0.13	* -0.48	0.05
Parental aspirations	0.22	0.15	0.13	0.05	0.09
Parent level of educ.	0.26	-0.06	** 0.15	0.18	0.05
Family income	* 0.23	0.12	** 0.06	0.09	* -0.10
Student feelings about math class	0.05	0.06	0.10	0.19	** 0.49
Student willingness to ask questions in class	0.09	* 0.39	0.03	0.02	-0.02
Student discussion with peers	-0.04	-0.36	-0.11	-0.34	0.11
Peer perception of student	** -0.83	* -0.46	0.00	-0.22	0.10
Weekday t.v. viewing	-0.16	-0.05	* -0.11	** -0.26	0.06
Weekend t.v. viewing	0.02	-0.11	0.03	0.09	-0.04

Note: A positive Beta coefficient is associated with a higher (more positive) outcome for males.

* = significant at the $p < 0.05$ level

** = significant at the $p < 0.01$ level

Table 4

Standardized Regression Coefficients for Productivity Factors with Significant Gender Differences Noted

Female Interaction Coeffient – Male Interaction Coefficient	Dependent Variables				
	Math IRT Achieve. Test Continuous	Math IRT Achieve. Test Top Quartile	Math Achieve. Coursework Levels 1 - 8	Math Achieve. Coursework Levels 6-8	Math Attitude
Prior Math Achiev.	0.00	-0.05	0.00	-0.02	0.00
Expectancy for Success	-0.11	0.20	-0.10	0.03	-0.09
Locus of Control	0.19	0.24	0.23	** 0.88	-0.24
Usefulness of Math	-0.68	* -0.63	0.05	-0.13	0.12
Class time per wk.	-0.37	-0.27	0.10	0.05	-0.05
Emphasis on Problem Solving	0.29	0.07	0.05	0.34	-0.18
Teacher preparedness	-0.66	* -0.98	0.06	0.07	0.39
Parental Support	0.23	0.10	-0.08	-0.49	0.00
Parent talks about high school plans	-0.84	-0.36	-0.06	0.02	0.36
Parental aspirations	0.30	0.16	-0.09	-0.06	0.01
Parent level of educ.	0.21	0.28	-0.01	0.21	-0.03
Family income	-0.08	-0.15	-0.04	-0.06	0.11
Student feelings about math class	* 0.65	-0.05	0.05	0.19	-0.11
Student willingness to ask questions in class	0.00	-0.11	-0.01	0.09	0.12
Student discussion with peers	-0.60	-0.07	0.18	* 0.61	-0.35
Peer perception of student	-0.32	-0.46	-0.16	-0.02	* -0.46
Weekday t.v. viewing	0.13	-0.12	0.04	-0.01	-0.11
Weekend t.v. viewing	0.18	** 0.40	0.05	0.12	0.11

* = significant at the $p < 0.05$ level

** = significant at the $p < 0.01$ level

Results and Discussion

In the discussion of the results below, symbols (+) and (-) are used to describe the relationship, positive or negative, of the significant Productivity Factors with the outcomes. A positive effect on Tables 5 and 6 means that more of that factor is associated with a higher score, more coursework, or more positive attitude, while a negative effect implies that more of that factor is associated with lower scores, less coursework, or a less positive attitude.

Factors for Females Mathematics Achievement Test

In an examination of which factors affected the female continuous achievement outcome, the following terms were significant at the

p <.05 level: student expectancy for success (+), perception of usefulness of math (-), parent aspirations (+), parent level of education (+), family income (+), and student discussion of high school plans with peers (-). At the p < .01 level, the following terms were significant for females: prior math achievement (+), class time per week (-), discussions with parents about high school plans (-), student feelings about math class (+), and peer perception of student (-).

For the dichotomous high test performance outcome, the following terms were significant for females at the p < .05 level: perception of usefulness of math (-), class time per week (-), student discussion of high school plans with peers (-), and weekend television viewing (+). At the p < .01 level, the following terms were significant for females: prior math achievement (+) and peer perception of student (-).

Mathematics achievement coursework. For the levels 1 - 8 math coursework outcome, the following terms were significant for females at the p < .05 level: parental discussion of high school plans (-), peer perception of student (-), and weekday television viewing (-). In addition, at the p < .01 level, the following terms were significant: prior math achievement (+), student expectancy for success (+), locus of control (+), parent level of education (+), student feelings about math class (+), and weekend television viewing (+).

With regard to the dichotomous advanced coursework outcome, only one term was significant for females at the p < .05 level: parental discussion about high school plans (-). At the p < .01 level, the following terms were significant for females: prior math achievement (+), expectancy for success (+), locus of control (+), parental level of education (+), student feelings about math class (+), weekday television viewing (-), and weekend television viewing (+).

Mathematics attitude. For the female attitude outcome, the following terms were significant for females at the p < .05 level: expectancy for success (-) and parental discussion about high school plans (+). At the p < .01 level, the following terms were significant for females: prior math achievement (+), perceived usefulness of math (+), student feelings about math class (+), and peer perceptions of the student (-).

Factors for Males

Mathematics Achievement Test. Looking at factors affecting the male continuous achievement test outcome, only one, family income (+), was significant at the p < .05 level. At p < .01 level, three factors, prior math achievement (+), expectancy for success (+), and peer perception of the student (-) were significant.

For factors affecting male dichotomous high test outcomes, student willingness to ask questions in math class (+) and peer perception of the student (-) were significant at the p < .05 level. At the p < .01 level, prior math achievement (+) and teacher preparedness (+) were significant.

Mathematics achievement coursework. With regard to the male levels 1 - 8 coursework outcome, only one factor, weekday television viewing (-), was significant at the p < .05 level. At the p < .01 level, prior math achievement (+), expectancy for success (+), parent level of education (+), and family income (+) are significant.

Looking at factors affecting the male dichotomous advanced coursework outcome, only parent talks about high school plans (-) was significant at the p < .05 level. At the p < .01 level, prior math achievement (+), expectancy for success (+), and weekday television viewing (-) were significant.

Mathematics attitude. With regard to factors affecting the male attitude outcome, only family income (-) was significant at the p < .05 level. At the p < .01 level, prior math achievement (+) and student feelings about math class (+) were significant.

Gender Differences in the Factors

The standardized regression coefficients representing gender differences in the Productivity Factors appear on Table 4. The numbers represent a measure of female standardized regression coefficients minus male standardized regression coefficients, and are not, in themselves, a measure of positive or negative relationships between the Productivity Factors and the outcomes.

Mathematics Achievement Test. Looking at whether there are gender differences in the productivity associations with the continuous achievement test outcome, only one term was found to be significantly different for males and females ($p < .05$), student feelings about attending math class. That factor had a higher, more positive association with the continuous achievement test outcome for females than for males (β = .70, β = .05, β =.65, representing the standardized regression coefficients for the females separately, males separately, and the difference between genders, respectively, as found in Tables 2-4).

An examination of gender differences in the productivity associations for the dichotomous high test outcome revealed two terms which were significantly different for males and females at the $p < 0.05$. They were perceived usefulness of math, (β = -.50,

β = .13, β = -.63, representing the standardized regression coefficients for the females separately, males separately, and the difference between genders, respectively, as found in Tables 2-4) and teacher feelings of preparedness to teach mathematics , (β = -.12, β = .86, β =-.98, representing the standardized regression coefficients for the females separately, males separately, and the difference between genders, respectively, as found in Tables 5 – 7). One factor, weekend television viewing, was significant at the $p < 0.01$, (β = .30, β = -.11, β = .40, representing the standardized regression coefficients for the females separately, males separately, and the difference between genders, respectively, as found in Tables 2-4).

Mathematics achievement coursework. Looking at whether there are gender differences in the productivity associations in the math coursework levels 1 - 8 outcome, the hierarchical regression run revealed no terms which were significantly different between males and females.

For the dichotomous advanced coursework outcome, one term, student discussion of high school plans with peers, was found to be significantly different for males and females at the $p < 0.05$ level (β = .27, β = -.34, β = .61, representing the standardized regression coefficients for the females separately, males separately, and the difference between genders, respectively, as found in Tables 2-4). At the $p < 0.01$ level, only one factor, locus of control, was significant (β = .75, β = -.14, β = .88, representing the standardized regression coefficients for the females separately, males separately, and the difference between genders, respectively, as found in Tables 2-4).

Mathematics attitude. In the math attitude outcome, the only term found to be significantly different ($p < 0.05$) for males and females was peer perception of student

(β = -.35, β = .10, β = -.46, representing the standardized regression coefficients for the females separately, males separately, and the difference between genders, respectively, as found in Tables 2-4).

Results Summary

The results of testing the hypothesis, looking at whether the Productivity Factors operate differently for males and females, showed several significant findings. With regard to the continuous math test outcome, a number of the Productivity Factors were significantly related to outcomes as pertaining to males and females (to be referred to henceforth as "male outcomes" and "female outcomes"). When comparing the difference between male and female effects, however, only one variable, student feelings about attending math class, operated significantly differently for males and females. In the dichotomous high test performance outcome, again, a number of variables were significantly related to the male and female outcomes. However, three variables showed significantly different effects for males and females: student view of usefulness of mathematics, teacher's view of preparedness to teach mathematics, and student weekend television viewing.

Although several of the Productivity Factors were significant for males and females in the levels 1 - 8 math coursework outcome, none of the variables operated significantly differently for males and females. In the advanced math coursework outcome, however, two variables, student discussion of high school plans with peers and locus of control, showed significantly different effects for males and females.

Finally, for the last outcome, math attitude, several of the Productivity Factors were related to the male and female attitude outcomes. However, only one variable, peer perception of student, had a significantly different effect for males and females.

Implications for Further Study

Results from the present study suggest that there are several factors in the Educational Productivity Model which impact mathematics achievement, coursework, and attitude. Additional research needs to be conducted to understand the effects noted in the present study. First, work needs to be done to see how the idea of usefulness of mathematics is perceived by 5^{th} to 8^{th} grade students. Is usefulness of math synonymous with practical, everyday math or is usefulness providing information on links to careers using math and technology? If it is the former, what changes can be made in the curriculum to provide career links and increase student interest in the math and science fields?

A second area for further study is in locus of control, or the lack of personal power issues surrounding adolescent and pre-adolescent females. What aspects of elementary and middle school experiences either cause or abet this loss of confidence for young women. Is this a problem unique to America or is something found in other cultures also? What are effective programs or interventions for young women that address this issue of self-confidence, and how do these impact possible success in mathematics achievement?

A third area for further research is the television viewing and, more currently, computer habits, of males and females. Has the computer replaced television as an academic distractor for both males and females? Does the time spent on computers (not doing homework) during the week relate to achievement and attitude outcomes. Does it differ by gender? What about weekend time for television viewing and computer use? Does this impact males and females differently?

A final area for future research is in the design of an Educational Productivity Model that might more accurately reflect the experiences of adolescent young women. As the NELS:88 base-year study did not include many questions assessing the classroom and peer group, the best representations of Walberg's Educational Productivity Factors in the base-year study were chosen. However, the author's experiences as a middle school math teacher suggest additional areas that can be examined to understand the math/educational experiences of young women. The struggle to encourage young women to work and achieve in mathematics, to expand their vision for the future, to develop, listen to, and express their voice is at the core of this study. What are the threads that create this multifaceted web of support for young women? What factors from the home, classroom, peer group, and out-of-school time affect young women's math achievement most strongly? Survey questions that assess cooperative learning in the classroom, size of the class and school, grade span of the school (is it K-8, 5-8, 6-8, 7-8, 7-9, etc.), the student's relationship with the teacher, and the student's relationships with other adult women are needed to gather a more complete picture of the adolescent young woman. For young women it is the connections they make, both literally (with other people) and figuratively (with ideas) that provide meaning in their lives. Further work must be done to provide and assess the quality of experiences we create for adolescent girls.

Conclusion

The U. S. Government, state governments, industry, and educators have set ambitious technological goals for the 21st century which must be pursued and realized for both males and females. From a policy point of view, it appears that one of the stumbling blocks present in attempting to increase the number of females entering technically oriented professions requiring a strong mathematics background is convincing elementary and middle school students on the value of a technical profession before they begin to "opt out" of the mathematics/technology pipeline (Wilson-Relyea, 1997).

In addition, the identification and removal of sources of mathematics gender bias in the classroom and the home must be addressed. These include those sources of bias which have been internalized by the female student due to past experiences with mathematics, classroom, peer and teacher interactions, and parental expectations. The lack of educational equity in mathematics for females is systemic, and it permeates all of society.

Fennema (1990) defines equity as equal educational opportunity, equal educational treatment, and equal educational outcome. To ensure all three, researchers, educators, and parents must carefully examine and address those alterable variables, from both the home and the schoolroom, that affect young women's attitude and achievement outcomes in mathematics.

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