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FEELINGS ABOUT MATH AND SCIENCE: RECIPROCAL DETERMINISM AND CATHOLIC SCHOOL EDUCATION

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Applying Bandura's reciprocal determinism model, differences in math and science experiences influenced by individual, gender, and school variables were investigated within 1,368 elementary students who attended 21 Catholic schools. Math and science were evaluated positively and favored more than other academic subjects. However, advantages were found for boys by lowered math anxiety levels and favoring of math, and for large schools by lowered math anxiety levels and higher student ratings of science. No advantages were found for small schools. However, school poverty rate appeared to have a confounding effect on school size. Discussion is presented pertaining to the specific need to study Catholic school systems regarding student perceptions in light of distinguishing Catholic school factors.

INTRODUCTION

As we live in a world that is increasingly dependent on advances in technology, it is imperative that education and socialization in the United States work to prevent negative bias against math and science education. Researchers have focused on various factors that explain this negativity; however, it is understood that both environmental and personal factors contribute to the problem. When negative math and science perceptions are formed, the student's potential to achieve favorably in these subjects is compromised. For example, 93% of Americans feel negatively about their past math education and more than two-thirds of U.S. adults are estimated to have math-related fear (Furner & Duffy, 2002). This implicates poor self-concept, low self-efficacy, negative attitudes regarding math (Ashcraft, 2002; Tocci & Engelhard, 1991), and unproductive behaviors such as avoiding math situations and taking fewer math courses (Hsiu-Zu et al., 2000; Preis & Biggs,

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2001). Similarly, negative attitudes regarding science are related to lower science achievement and science avoidance behaviors (Chipman, Krantz, & Silver, 1992; Freedman, 1997). Advocates of reforms in math and science education (Heuser, 2000; Tobias, 1991) encourage improvements in the school environment that boost the levels of comfort, interest, and perceived value of these critical academic areas.

Because of the extensive degree of variation within U.S. educational systems, research is called for that investigates the circumstances under which children from various educational settings are progressing in math and science. Research conducted in non-Catholic school settings has found that factors in the school setting are associated with student attitudes and achievement in math (Furner & Duffy, 2002; Jackson & Leffingwell, 1999; Midgley, Feldlaufer, & Eccles, 1989) and science (Arambula-Greenfield & Feldman, 1997; Ikpa, 2003; Sandoval, 1995). Yet, the Catholic educational system offers an opportune setting to examine environmental and personal factors related to math and science education for reasons related to the assumed differences in student population and school environment.

First, the identity of the Catholic school environment may provide unique advantages for students' overall well-being as Catholic schools as part of a diocese are distinguished by their combined educational and religious objectives that encourage shared values, as well as a sense of community and belonging (Hudson, 2003). Furthermore, students who experience this type of Catholic education may also experience more frequent parental involvement (Mulligan, 2003) and teacher commitment and involvement at school than students who attend public schools (Cimino, Haney, & Jacobs, 2000).

Second, the identity of the Catholic school student seems to have some degree of distinctiveness. Evidence has been found that students attending religious schools, compared to public school students, tended to fare better in terms of academic achievement, self-discipline, and responsibility (Bryk, Lee, & Holland, 1993). These advantages may actually be explained by the student's and school's religious commitment (Jeynes, 2003). As individuals interact with their learning environment, they transmit and receive messages that portray them engaging in the learning process confidently or awkwardly, comfortably or distressingly. When students feel connected and supported in their learning environments, it is expected that their learning in general, and their math and science learning is positively influenced.

The question whether the Catholic school setting would also fare as advantageous in regard to math and science in particular has received minimum targeted research. Earlier findings show that attending Catholic schools compared to public schools had a positive effect on math achievement within elementary school (Sander, 1996) and high school (Hoffer, Greeley, & Coleman, 1985), while Catholic school advantages for science achievement were not demonstrated (Sander, 1996). Even so, earlier findings may not apply today, and the previously reported advantages may not have generalized well, considering earlier research findings that these advantages may be mainly experienced by non-Catholic students and ethnic minorities who attend Catholic grade schools (Hoffer et al., 1985; Sander, 1996).

SOCIAL COGNITIVE THEORY

Bandura's (1977, 1978) advancement of the Social Learning Theory in his model of reciprocal determinism provides an appropriate framework to examine how math and science learning is influenced by Catholic school environmental factors and student dynamics. This model stresses the interactive links among three influences on human learning: (a) the environment pertaining to learning, including resources, learning experiences, and the social influences an individual receives from others in the learning climate; (b) the personal and psychological aspects of an individual; and (c) the behavior that is put into action by the individual. The premise of reciprocal determinism is that interconnected relationships, which may be visualized as a complex network of links between all the experiences that support the specific learning process, matter.

To understand how Bandura's reciprocal determinism may apply to the learning of math or science, consider an individual's formation of the personal belief, "I like math" as a personal-internal link toward learning math. Therefore, "I like math" develops as a network of interactions, including the various internal characteristics (e.g., positive math expectations), personal behaviors (e.g., practicing math), and external-environmental exchanges (e.g., quality math resources) that manifest as a personal cognition linked to the person's behaviors and experiences. Table 1 presents a matrix of this study's variables based on reciprocal determinism that suggests the various reciprocal links involved in support of a positive learning experience of math or science. For the sake of clarity, the author has divided Bandura's personal category into two subcategories: personal-internal (cognitions, abilities, attitudes) and personal-social (sex, age, race).

Table 1

Proposed Reciprocal Determinants Supportive of Math or Science (M/S) Learning

Linked determinants	Study variables	Study measures
Personal-Internal Favorable abilities, cognitions, affect for M/S	Cognitive perception of M/S	Best subject is M/S (YFAS)
	Affective-Behavioral perception of M/S	Like M/S (YFAS)
		Feel bad—M/S (YFAS)
	Math anxiety	Math anxiety (MASC)
Personal-Behavioral Positive performance, achievement, practice in M/S	Affective-Behavioral perception of M/S	Good at M/S (YFAS)
Personal-Social Sex, age, gender, ethnicity, SES, etc.	Gender influence on M/S	Gender (YFAS)
Environmental Setting, opportunities, resources, influences, rewards for M/S	Grade level influence on M/S	Grade level (YFAS)
	School enrollment size influence on M/S	School (YFAS)

An important idea in reciprocal determinism is that personal attributes, behavioral experiences, and environmental experiences may be inputs as well as outcomes. For example, a cognition that is pro-science may lead a student to engage in supportive science activities and may improve his or her science achievement. Yet, when science opportunities in the student's environment are not supportive of his or her personal attributes, one might develop avoidance behaviors that negatively impact science achievement. Consequently, reciprocal determinism has implications for external validity, the extent that research findings can be generalized across individuals, settings, and variables. Because changes in the learning environment may both influence and be influenced by factors related to the individual's learning experience, research findings should be cautiously generalized. The degree of certainty in which conclusions about learning can be applied across different educational systems is contingent upon evidence from these different educational settings.

RATIONALE AND AIMS OF PRESENT STUDY

This study offers a unique approach to examine a Catholic elementary school system by applying Bandura's model of reciprocal determinism to math and science learning. Catholic grade school students have not been studied in the research on math- or science-related attitudes, and non-Catholic samples may not generalize. Further, the samples used in the studies that reported favorable Catholic school findings specific to math and science test scores are around two decades old. In addition, research is lacking that examines Catholic elementary school students for math anxiety, an important construct related to math achievement and performance. Consistent with the reciprocal determinism theory, the present study focused on understanding how positively did Catholic elementary school students experience the personal, behavioral, and environmental influences associated with math and science learning and the relationships among these influences. Three specific objectives were addressed in this study.

First, this study determined the proportion of Catholic school elementary students who would positively identify with math or science (M/S) by selecting M/S as their best school subjects. Applying reciprocal determinism, students who possess attitudes that either reflect or promote positive mindsets about math and science are apparently engaging in a learning environment in such a way that their achievement in these subjects is advanced. Therefore, the findings from this objective would indicate whether M/S was experienced positively or negatively as represented by the personal-internal determinant that is linked to the environmental determinant, the overall Catholic school system in this study.

Second, this study investigated personal-internal and personal-behavioral links by studying the associations among personal-internal, affective-behavioral perceptions—such as "I like math/science," or "I dislike math/science"—and self-reported personal behaviors, such as "I am good at math/science." Math anxiety, the feeling of tension, apprehension, or fear that interferes with math-learning cognitions and long-term educational performance, provides a good example of a learning determinant that comprises relationships among cognitions, emotions, and behaviors that influence and are influenced by the learning environment (Ashcraft, 2002; Hembree, 1990). We hypothesized a positive relationship between liking math/science and being good at math/science and a negative relationship between these two variables and math anxiety.

The third specific aim was to explore the influence of gender and school environmental factors, such as school size and grade level, on students' personal cognitions and affective-behavioral perceptions (math anxiety, best subjects, liking math/science) and self-reported behavior (good at math/science). Research findings from the past decades that examined correlates of math and science learning related to gender are mixed (Hyde, Fennema, Ryan, Frost, & Hopp, 1990), however, when advantages are reported, they continue to favor males over females (Casey, Nuttall, & Pezaris, 1997; Freedman, 2002). We investigated whether boys in the Catholic school environment would have less math anxiety and select math and science at higher rates than girls and whether specific school environmental determinants (grade level and school size) would influence math- and science-related perceptions within this Catholic school environment. School setting variables have been linked to math-science expectations and attitudes in non-Catholic school settings with an advantage for lower grade levels (Ma, 2003) and some support for larger schools (Ma, 2001).

Considering the long-established link between socioeconomic status and academic achievement (White, 1982), we also examined the relationship between school poverty level and school size as Catholic schools in economically disadvantaged communities tend to have smaller enrollment.

METHOD

PARTICIPANTS

The sample consisted of 1,368 elementary school children from 21 Catholic schools located within a U.S. midwestern metropolitan area. These students were the baseline sample of a math and science enrichment program for teachers. The sample was comprised of 547 fourth graders (40%), 242 fifth graders (17.7%), and 579 sixth graders (42.3%). There were 716 (52.3%) girls and 652 (47.7%) boys. No data about the students' ethnicity or race were collected.

SCHOOLS

Schools were part of the same archdiocese with enrollment sizes that ranged from 129 to 1,061 students. There were 517 participants who attended schools with large enrollment (731 to 1,061 enrolled), 465 participants who attended schools with medium enrollment (376 to 617), and 387 participants who attended schools with the smallest enrollment (129 to 293).

MATERIALS

Students' math anxiety was measured using the Math Anxiety Scale for Children (MASC; Chiu & Henry, 1990). The MASC consists of 22 items in which children rate situations related to math on a 4-point Likert-type scale in terms of how much anxiety they experience. The MASC was developed from the revised short version of the Math Anxiety Rating Scale (MARS; Plake & Parker, 1982). Chiu and Henry (1990) reported modest to moderate relationships (r = -.24 to -.47) between MASC scores and the final math grades of fourth through sixth-grade students. The MASC content appears very similar to the MARS-E (Suinn, Taylor, & Edwards, 1988), though we found the MASC items to be less lengthy and presumably easier for the fourth graders to comprehend. Beasley, Long, and Natali (2001) tested the validity of different factor models of the MASC based on a sample of 278 sixth-grade students and reported a Cronbach's alpha of .924, concluding that math anxiety among children as measured by the MASC may be a unidimensional construct. Examples of MASC items include situations such as "starting a new chapter in a math book" and "taking a quiz in a math class."

In addition to the math anxiety measure, the Your Feelings About School questionnaire (YFAS), was developed by the researchers to measure personal-internal and personal-behavioral determinants in light of the reciprocal determinism model. It includes an open-ended question that asks students to identify their best subject in school (a personal-internal, cognitive perception of academic subject). A 9-item scale measures affective and behavioral perceptions of math, science, and the student's identified best subject. These items are the degree to which students like math, science, and their best subject; do not feel bad about these subjects; and their perception of being good at these subjects. The response scale for each affective and behavioral perception item is 0-2; where 2 is most favorable. The three items per subject are combined into composite scores, which are referred to as a student's affective-behavioral perception for math, science, and their best subject.

DESIGN AND PROCEDURE

Students were recruited from each school as the principals informed students about their school's participation in the teacher enrichment program. A research team comprised mainly of doctoral-level psychology students and supervised undergraduate research assistants administered measures at the schools. To avoid problems with internal validity by administering the questionnaires during math and science classes, the majority of schools allowed their students to assemble in their libraries, cafeterias, or auditoriums during a nonacademic time. There were 1,386 fourth, fifth, and sixth-grade students who completed the Your Feelings About School questionnaire in their respective schools. Only the fourth-grade students (n = 547) were administered the Math Anxiety Scale for Children (Chiu & Henry, 1990).

RESULTS

AIM ONE: PERSONAL-INTERNAL DETERMINANT-COGNITIVE PERCEPTIONS OF M/S

Cognitive perception was measured by the first item on the YFAS questionnaire (i.e., best subject in school). The frequency and percentage of students' selections of their best subjects are presented in Table 2, grouped by overall results and by gender, and in Table 3 grouped by school environment variables. As shown in Table 2, math (25.5%, n = 344) and science (19.1%, n = 255) were the top two choices. The low-frequency responses of health/physical education (0.6%) and miscellaneous subjects, like "play" (0.4%) were not included. There was an overall significant difference, x^2 (5, n = 1337) = 208, $p < .01$, among selected best subjects. Subsequent testing revealed that significantly more students selected math than any other subject, while science was the second overall choice (18.9%), x^2 (1, n = 599) = 13.2, $p < .01$. The p-values for the subsequent tests were adjusted using the Bonferroni correction.

Table 2

Frequencies and Percentages of Perceived Best Subject—Overall and by Gender

Perceived best subject	Overall		Boys		Girls	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Mathematics	344	25.7	192	30.2	152	21.6
Science	255	19.1	145	22.8	110	15.7
Social studies	236	17.6	122	19.2	114	16.2
Verbal	232	17.4	70	11.0	162	23.1
Art-Music	222	16.6	88	13.9	134	19.1
Religion	48	3.6	18	2.8	30	4.3

Table 3

Mathematics or Science is Best Subject by School and Gender Variables

Variable	Mathematics		Science	
	Frequency	Percentage	Frequency	Percentage
Grade level				
4	147	27.2	87	16.1
5	74	30.7	51	21.2
6	123	22.1	117	21.0
School size				
Small	90	25.0	74	20.2
Medium	136	29.7	73	16.0
Large	118	23.0	108	21.0
Gender				
Boys	192	30.2	145	22.8
Girls	152	21.6	110	15.7
All	344	25.7	255	19.1

AIM TWO: PERSONAL-INTERNAL (AFFECTIVE) AND PERSONAL-BEHAVIORAL PERCEPTIONS OF M/S

Descriptive statistics and bivariate correlations are listed in Table 4 for each item in the YFAS scale. Students' affective-behavioral perceptions for math and science were both positive, however, the results of a paired *t*-test showed a higher score for science (M = 4.67, SD = 1.45) compared to math (M = 4.31, SD = 1.62), t (1354) = 6.40, p <.0001. As shown in Table 4, there were moderate relationships among the three items that measure students' affective-behavioral perceptions for math: like math and good at math (r = 0.46); like math and do not feel bad about math (r = 0.49); good at math and do not feel bad about math (r = 0.40), with Cronbach's alpha of 0.71. In addition, there were moderate relationships among the three items that measure students' affective-behavioral perceptions for science: like science and good at science (r = 0.38); like science and do not feel bad about science (r = 0.39); and good at science and do not feel bad about science (r = 0.39), with Cronbach's alpha of 0.65.

Table 4

Descriptives and Bivariate Correlations for YFAS Items

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
1. Like best subject	1.79	0.45		.24	.14	.26	.08	.07	.30	.09	.08
2. Feel bad about best subject	1.84	0.42			.15	.08	.33	.08	.13	.32	.11
3. Good at best subject	1.85	0.37				.09	.12	.32	.10	.09	.29
4. Like science	1.42	0.70					.38	.38	.04	.03	.03
5. Feel bad about science	1.67	0.60						.39	.03	.26	.05
6. Good at science	1.58	0.58							.04	.07	.20
7. Like math	1.29	0.74								.49	.46
8. Feel bad about math	1.54	0.66									.40
9. Good at math	1.48	0.62									

Math anxiety was measured using 19 of the 22 MASC items after three items (2, 11, and 14) were removed from scoring because students frequently questioned the meaning of these questions. Subsequent discussion with fourth-grade teachers verified that students were yet to be introduced to the expressions used in these MASC items, namely interpreting graphs and formulas in science. Therefore, based on the adjusted mean for the current sample of fourth graders (M = 37.01, SD = 12.01), a weighted comparison of the MASC scores was conducted against the 40 fourth graders in Chiu and Henry's (1990) original sample (M = 35.50, SD = 10.02). The results revealed that the math anxiety scores of the present sample of fourth graders were significantly higher than those of the fourth graders in the 1990 sample, t (488) = 2.76, $p < .01$. The MASC developers (Chiu & Henry, 1990) have not published guidelines on clinically significant cutoff points for this measure.

The relationships among math anxiety, math affective-behavioral perception, and science affective-behavioral perception were explored using Pearson product moment correlation and multiple regression analysis. Table 5 lists the descriptive statistics and bivariate correlations for math anxiety, and the YFAS composite scores for math, science, and best subject. There was a strong negative correlation between math anxiety and the affective-behavioral perceptions of math (r = -0.51, n = 489, p < .001). As listed in Table 5, there was a small negative relationship between math anxiety and affective-behavioral perceptions for science (r = -0.23, n = 488, p < .001).

Table 5

Bivariate Correlations for Composite Variables of Affective Perception

Composite variables	*M*	*SD*	1	2	3	4
1. Affective-Behavioral perception of best subject	5.48	0.84		.30 (1363)	.32 (1366)	-.29 (488)
2. Affective-Behavioral perception of science	4.67	1.45	.30 (1363)		.13 (1365)	-.23 (488)
3. Affective-Behavioral perception of mathematics	4.31	1.62	.32 (1366)	.13 (1365)		-.51 (489)
4. Math anxiety MASC	37.01	12.01	-.29 (488)	-.23 (488)	-.51 (489)	

Note. MASC mean score was adjusted based on using 19 of the 22 items.

AIM THREE: RELATIONSHIPS AMONG PERSONAL-SOCIAL AND ENVIRONMENTAL DETERMINANTS AND M/S

The roles of gender, school size, and grade level were examined in regard to the study's variables involved in learning math and science. Additional descriptive and correlational analyses were performed to determine the relationship between school size and student poverty rate, a potentially important school environmental determinant.

COGNITIVE PERCEPTIONS OF M/S

Using multiple logistic regression analysis, three conditions were all statistically significantly associated with choice of math as the perceived best subject. One condition is being male compared to female (odds ratio = 1.5; 95% confidence interval: 1.2, 2.0). Boys chose math (30.2%) at a higher rate than the next highest subject, science (22.8%). The second condition is being in fifth grade compared to sixth grade (odds ratio = 1.7; 95% confidence interval: 1.1, 2.2). Fifth graders selected math most frequently (30.7%) as their best subject followed by science (22.1%). The third condition is attending a medium-sized compared to large school (odds ratio = 1.5; 95% confidence interval: 1.1, 2.0). Students from the medium-sized schools selected math (29.4%) most frequently as their best subject followed by social studies (18.8%).

AFFECTIVE-BEHAVIORAL VARIABLES

Analysis of variance was used to determine if the independent variables of gender, school size, and student grade level had an effect on affective-behavioral perceptions of math. Table 6 lists the findings on the effects of gender and school variables on outcome variables of math and science affect and math anxiety. There was no statistically significant effect for gender, F (1, 1362) = 0.43, *ns*, or school size, F (2, 1362) = 0.66, *ns*. However, there was a statistically significant effect for grade level on affective-behavioral perception of math, F (2, 1362) = 10.41, $p < .01$. Posthoc, Bonferroni adjusted tests indicated that sixth graders (M = 4.08, SD = 1.61) had less positive affect for math compared to fourth graders (M = 4.44, SD = 1.60, $p < .01$) and fifth graders (M = 4.55, SD = 1.64, $p < .01$).

Analysis of variance was used to determine whether gender, school size, and student grade level had an effect on affective-behavioral perceptions of science. There was no statistically significant effect for gender, F (1, 1359) = 3.34, *ns*, or grade level, F (2, 1359) = 0.88, *ns*. However, there was a statistically significant effect for school size, F (2, 1359) = 13.18, $p < .01$ on science affect. Posthoc tests revealed significant differences between large schools (M = 4.90, SD = 1.46), compared to the medium (M = 4.43, SD = 1.46, $p < .01$) and small schools (M = 4.64, SD = 1.51, $p < .03$).

In addition, analysis of variance was also used to determine if gender, grade level, and school size had an effect on the difference between students' ratings of their affective-behavioral perceptions of science compared to math. Table 7 lists the mean difference scores comparing affective-behavioral perception for math to science, grouped by gender, grade level, and school size. Gender did not have a significant effect, F (1, 1359) = 0.55, *ns*, while the difference between science and math affective-behavioral perceptions were significantly effected by grade level, F (2, 1359) = 4.73, $p < .05$, and school size, F (2, 1359) = 4.73, $p < .05$. Feelings about science were more positive than math for both boys and girls, fourth and sixth grade students, and students at the largest and smallest schools. Posthoc Bonferroni corrected tests revealed that the difference between science and math ratings was significantly higher for sixth graders compared to fifth graders ($p < .01$); and in the large schools compared to the medium schools ($p < .01$). All other students did not differ significantly in their math and science ratings.

Table 7

Influence of Gender and School Variables on Mean Difference Scores Between Science and Math Affect

	Science versus math affective perceptions Mean (*SD*) Difference *p*		
Gender	Boys	Girls	
	Science > Math 0.25 (2.13) *p* < .01	Science > Math 0.34 (2.11) *p* < .01	
Grade level	4	5	6
	Science > Math 0.27 (1.67) *p* < .01	Science = Math 0.08 (2.01) *NS*	Science > Math 0.52 (2.02) *p* < .01
School size	Small	Medium	Large
	Science > Math 0.34 (2.14) *p* < .01	Science = Math 0.05 (2.06) *NS*	Science > Math 0.49 (2.04) *p* < .01

MATH ANXIETY

The strength of the relationship between math anxiety and the affective-behavioral perceptions of math did not differ significantly (t = 0.54, *ns*) between girls (r = -0.49, n = 245) and boys (r = -0.52, n = 244), or between students at small (r = -.50, n = 160), medium (r = -.57, n = 188), and large schools (r = -.46. n = 141), t = 1.69, *ns*. The strength of the relationship between math anxiety and affective-behavioral perceptions for science did not differ significantly (t = 1.38, *ns*) between girls (r = -0.16, n = 245) and boys (r = -0.29, n = 243), or between between students at small (r = -0.26, n = 159) medium (r = -0.24, n = 188), and large schools (r = -0.09, n = 141), t = 1.23, *ns*.

A two-way between groups ANOVA was conducted to explore the impact of gender and school size on respondents' levels of math anxiety. There was a statistically significant main effect for gender, F (1,485) = 11.81, $p < .01$. Girls scored higher on the MASC (M = 33.41, SD = 10.30) indicating a higher level of math anxiety symptoms for girls compared to boys (M = 30.21, SD = 10.34) in the study. There was also a significant main effect for school size, F (2,485) = 3.90, $p < .05$. The interaction effect did not reach statistical significance F (2,483) = 0.64, *ns*. Post hoc comparisons of the least-square means, using a Bonferroni correction indicated that respondents' mean math anxiety score within the large schools (M = 30.22, SD = 10.28) was significantly different ($p < .05$) than the mean math anxiety score within the medium schools (M = 33.41, SD = 10.28). The mean MASC score for respondents at the small schools (M = 31.79, SD = 10.28) did not differ significantly from the respondents at either the medium or large schools.

ADDITIONAL ANALYSIS: ROLE OF SCHOOL POVERTY DETERMINANT

Almost two-thirds (64.5%, n = 873) of the overall sample attended schools where no more than 5% of students received federal subsidy for school lunch, an indicator of schools' poverty levels. In the large schools (2% to 8%) and the medium-sized schools (3% to 13%), there were very low enrollments of students who qualified for federal lunch subsidy. Conversely, small schools were heterogeneous schools in terms of their schools' eligibility for federal lunch subsidy, which ranged from 2% to 80%. However, only the small schools in this study had one fifth or more enrolled students who qualified for federal lunch subsidy. Correlational analysis showed a strong negative correlation between school enrollment size and school's percentage of federally subsidized students (r = -0.66), revealing that the students who attend the smallest schools have the highest poverty levels. Further, the Kruskal-Wallis test (p = 0.02) revealed that the smaller schools had significantly higher school poverty rates than the medium-sized and large schools.

DISCUSSION

This study investigated a particular learning environment, a Catholic elementary school system, in regard to math and science learning as related to Bandura's model of reciprocal determinism. Specifically, we examined whether fourth through sixth graders attending Catholic schools held positive associations of their math and science subjects based on students' perceived cognitions, affect, behavior, and levels of math anxiety.

The first aim of this study explored the reciprocal determinism model concerning a personal-internal determinant (the cognitive observation of math and science) associated with students' learning environment (i.e., "what is your best subject in school?"). If a significant proportion of students in the overall school environment selected math or science as their best subject without prompt, then the environment and students are interacting in such a way that is supportive of math or science learning. More than 25% of overall students selected math as their best subjects and nearly 20% selected science. At first glance, math was the top choice, significantly preferred over science, social studies, verbal academics, arts or music, and religion. These findings can be interpreted favorably in light of research on subject specific cognitions of self-efficacy (Bong, 2004; Pajares & Miller, 1995; Sandoval, 1995) that emphasizes the value of positive cognitions held exclusively for math and science in promoting successful learning environments that support immediate and long-term math/science achievement. Still, math and science perceptions in this environment may be better understood in light of associated reciprocal determinants that are discussed below.

The second specific aim explored the reciprocal determinism model with regard to the linked personal-internal and personal-behavioral determinants, revealing three main findings. First, overall students were more likely to believe they were good at math and science, to like these subjects, and not feel bad about them. However, overall students' affective-behavioral perceptions of science were significantly more positive, compared to math. Second, students who felt positive about math or science, perceived themselves to perform better in these subjects, and those who perceived themselves to perform poorer were also more likely to feel negative about these subjects. Third, when students reported lower levels of math anxiety, they also held positive evaluations of their affective-behavioral perceptions of math and science. This negative relationship was expected for the affective-behavioral perceptions of math, given that math anxiety as measured by the MASC assesses affect and behavior. Our findings are in accord with previous research on non-Catholic students that links self-perceptions and behaviors related to math and science learning (Pietsch, Walker, & Chapman, 2003; Rouxel, 2000; Singh, Granville, & Dika, 2002) and research that associates math anxiety with dissuading personal attitudes and behaviors, such as avoiding math situations, and taking fewer math-related courses (Ma, 1999; Preis & Biggs, 2001; Tobias, 1991). While some evidence has been found that math anxiety has been negatively associated with interest in science education and careers (Chipman et al., 1992), the need to understand math and science subjects as two distinct learning areas is also necessary (Sandoval, 1995). To better understand the learning experience of math compared to science reported by our Catholic school students, necessary consideration is given to other personal-social and environmental factors that may be operating as discussed next.

The third aim investigated the roles of the personal-social determinant (gender) and school environmental determinants (school size, grade level) associated with students' personal characteristics and behaviors (i.e., best subject, math anxiety, affective-behavioral perceptions) relative to math and science learning. Gender, grade-level, and school size were all influential in their roles relating to math or science learning.

THE ROLE OF PERSONAL-SOCIAL DETERMINANT, GENDER

Students were significantly more likely to have pro-math and pro-science personal-internal cognitions (i.e., choose math as their best subject) if they were male. Boys more often selected math, followed by science as their best subjects, while girls' selections varied among the subjects. In addition, girls in this sample reported higher levels of math anxiety symptoms, thus interacting in the math-learning environment in a manner that may well limit their performance. The personal-social determinant of gender interacts in the learning environment less favorably for girls compared to boys. Although mixed findings have been found in non-Catholic schools (Chiu & Henry, 1990; Gierl & Bisanz, 1995; Heyman & Legare, 2004; Wigfield & Meece, 1988), girls are more likely to experience higher levels of math discomfort or anxiety (Betz, 1978; Rouxel, 2000; Tocci & Engelhard, 1991), and have less positive attitudes for math and science (Betz & Hackett, 1983; Hyde et al., 1990; Weinburgh, 1995). Aptitude differences do not explain these disadvantages (Casey et al., 1997; Lubinski & Benbow, 1992).

THE ROLE OF SCHOOL ENVIRONMENT DETERMINANT, GRADE-LEVEL

Students were significantly more likely to choose math as their best subject if they were in fifth grade. Moreover, sixth-grade students interacted in the environment in regard to learning math in ways that involved a less positive experience of affect and behavior specific to math, compared to fourth and fifth graders. In addition, being in sixth grade provided a different math/science learning experience, such that sixth graders revealed more positive affective-behavioral experiences for science than math. Our findings are not unlike research in the non-Catholic schools that shows that positive math attitudes are more likely during the earlier years and negative math attitudes increase as children advance in school (Eccles, Wigfield, Harold, & Blumenfeld, 1993; Gierl & Bisanz, 1995; Perlmutter, Bloom, Rose, & Rogers, 1997; Rech, 1994), peaking during middle school (Ma, 2003). However, our findings that science became most appealing in the sixth grade, to our knowledge has not been reported in the literature and may be a phenomenon specific to this Catholic school system.

THE ROLE OF SCHOOL ENVIRONMENT DETERMINANTS, ENROLLMENT SIZE AND POVERTY-RATE

Students who attended the medium-sized schools were more likely to select math as their best subject. Students who attended the larger schools reported the most positive affect for science and had learning experiences that involved lower levels of math anxiety. There were no advantages found at the small schools in regard to our math or science affective and behavioral learning determinants. These findings are contrary to what was expected and has been shown in the non-Catholic environment. The small school is usually seen as the nurturing setting (Ma, 2001) with associated support and adaptations which should be reflected in more positive affect and lower levels of anxiety.

Our findings that school poverty rate was strongly, negatively related to school enrollment size, and that only our small schools had perceptible rates of students who qualified for federal lunch subsidy, provides a rather palpable argument. We found support for Ma's (2001) proposal that math and science advantages might be explained by apparent funding advantages in large compared to small schools. Our results emphasize the need to study Catholic school settings separately in regard to educational-environmental determinants and associations. The only measure of social disparity was the percent of subsidized lunches, which was significantly higher for the small schools. The confounding of these two factors may be distinctive in regard to the Catholic school environment. Given that today's Catholic educational system comprises two distinct settings, one serves low income, predominantly ethnic minority students, and one serves the rather affluent, Caucasian students (Hallinan, 2002), our findings may point to timely academic-related consequences of this disparity. Already noted in the recent literature from non-Catholic school settings are math-science educational shortcomings associated with limited financial resources and ethnic minority group membership.

For example, lower family income creates various educational disadvantages, including less positive feelings about math (Furner & Berman, 2003), while higher family income provides access to technologically superior, and innovative approaches to math and science (Yang, 2003). Further, ethnic minority students are seldom exposed to role models with careers in science and technology and receive the least encouragement to pursue related subjects (Leitman, Binns, & Unni, 1995; Rech, 1994). In the case of the school environment studied here, it would be misleading to emphasize the size of the school as problematic or advantageous regarding math or science learning without taking into account the advantages that large schools in this setting may share, associated with higher affluence or very low rates of students who are financially disadvantaged.

THEORETICAL IMPLICATIONS

Although math and science courses have been negatively portrayed in the US as inherently difficult, unpleasant, and anxiety-provoking, the current sample of Catholic elementary students reported quite favorable perceptions of their school experiences of math and science. Moreover, findings from the third aim of this study may be understood as the core of the reciprocal determinism model, which highlights certain advantages within a Catholic educational environment relative to positive perceptions, emotions, and behaviors associated with math and science learning, and challenges the assumptions of a generalized positive experience across these schools. Because reciprocal determinism better informs us how the individual students and their learning environment possibly will interact in a learning process, this model is appropriate for examining how math-science learning determinants are associated within the Catholic school system, an educational system that is distinguished as being a community. Given the school-community conceptualization, the reciprocal interaction between schools and students involved in learning may well be experienced as a kind of synergism. As in the case of school poverty level, the students attending the small schools, comprised of the most financially needy families, may have higher demands on the schools, yet have limited access to important cost-prohibitive math-science resources at school, such as advanced technology or specialized teachers. Although in our study, we were unaware of an individual student's financial situation, educators in these smaller Catholic schools are constantly reminded of the personal-social challenges experienced by up to 80% of their students who receive federal subsidy. Moreover, financially disadvantaged students are unlikely to experience math-science supportive resources outside of school, and their families are unlikely to have the means to augment the school's shared or community resources. Alternately, the synergistic, reciprocal effect might actually benefit financially disadvantaged students who attend the medium-sized and larger schools in this study as their learning interactions are positively influenced by sharing the resources of schools that are more fiscally solvent.

In regard to the girls in our sample, there is room for improvement in light of the more positive perceptions of math experiences held by their male counterparts. Unlike the situation of the personal-school environmental link, which calls for providing the smaller schools with the same access to resources shared at the larger schools, the disadvantages associated with female students calls for providing access to different resources at school for math learning in particular. Perhaps girl-specific math programs would counter their less positive attitudes and those negative effects from the larger social environment that dissuades girls from math. The Catholic school system has already established a precedent for gender-only schools, so the early introduction of math- and technology-related, gender-only programs in elementary schools may further enhance the value of a Catholic school education. Some researchers have already suggested that as attitudes are improving, the gender gap is vanishing for math (Campbell & Evans, 1997; Heyman & Legare, 2004) and science (Arambula-Greenfield & Feldman, 1997; Freedman, 2002). Our findings may be useful to the educators and decision makers on behalf of Catholic elementary schools by revealing areas of concentration to improve students' experiences of math and science learning.

LIMITATIONS

Some characteristics of this study present limitations. One limitation of this study is that it relies on children's perceptions and self-reports. Collaborating reports regarding students' behaviors related to math and science, such as school performance achievement records, may provide a different representation of these students' academic behaviors and performance in math and science. Another limitation is in regard to the unavailability of precise data concerning the economic situation of the school and individual student. Our only measure, percentage of students who qualified for federal lunch subsidy, did not allow us to measure the relative contribution of school size versus poverty index due to the confounding of these factors. Further, this measure does not necessarily indicate the financial resources utilized at these schools relevant to the learning of math and science, such as discrepancies in accessibility of new technologies.

FURTHER RESEARCH

Adding objective data such as math and science achievement scores would enhance the interpretation of the students' perceptions of their abilities. Follow-up of these students, in particular the fourth graders, as they progress through grade levels would give insight into their changing perceptions and math anxiety over time, with focus on possibility for positive intervention. Inclusion of student demographic variables and an investigation of how the personal and school demographic variables interact with math and science learning would expand the understanding of the Catholic school environment in regard to reciprocal determinism and differences in educational experiences.

In conclusion, in light of the social cognitive theory (Bandura, 1978), the examination of fourth through sixth-grade Catholic school students demonstrated that students in this environment had positive perceptions and feelings for both math and science, while their personal experiences of math anxiety, academic preferences, and affective-behavioral perceptions of math and science varied according to their gender and school environmental factors. Girls and students at the smallest schools had the least favorable results, while school poverty rate appeared to have a confounding effect on school size. These findings that the social, school environment, and personal variables all work together to shape students' math and science experiences demonstrate Bandura's reciprocal determinism model in regard to math and science education particular to Catholic elementary schools.

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