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Editor's Note: This study by Saritas and Akdemir relates student variables, contextual variables, and design options that influence learning and relate them to mathematics achievement. Their results highlight the need to customize instruction to optimize the performance of each individual student. Instructional designers need to develop flexible teaching and learning based on awareness of students' experience and background, subject matter, and instructional communications and technology.

Identifying Factors Affecting the Mathematics Achievement of Students for Better Instructional Design

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Abstract

The quality of teaching and learning mathematics has been one of the major challenges and concerns of educators. Instructional design is an effective way to alleviate problems related to the quality of teaching and learning mathematics. Knowing the factors affecting math achievement is particularly important for making the best design decisions. This study was conducted to identify the factors affecting the math achievement of students through collecting the opinions of math department students. Results revealed that instructional strategies and methods, teacher competency in math education, and motivation or concentration were the three most influential factors that should be considered in the design decisions.

Introduction

As is the case in the past, most people today still believe that mathematics is all about computation. However, computation, for mathematicians, is merely a tool for comprehending structures, relationships and patterns of mathematical concepts, and therefore producing solutions for complex real life problems. This perspective of mathematicians has gained more attention and importance with rapid advancements in information and communication technologies. It has become necessity for people of all ages to reach, analyze, and apply the mathematical knowledge effectively and efficiently to be successful citizens in our information age. In particular, students need to be well-equipped with higher-order mathematical knowledge.

The quality of teaching and learning in mathematics is a major challenge and for educators. General concern about mathematics achievement has been evident for the last 20 years. The current debate among scholars is what students should learn to be successful in mathematics. The discussion emphasizes new instructional design techniques to produce individuals who can understand and apply fundamental mathematic concepts. A central and persisting issue is how to provide instructional environments, conditions, methods, and solutions that achieve learning goals for students with different skill and ability levels. Innovative instructional approaches and techniques should be developed to ensure that students become successful learners.

It is important for educators to adopt instructional design techniques to attain higher achievement rates in mathematics. (Rasmussen & Marrongelle, 2006). Considering students' needs and comprehension of higher-order mathematical knowledge, instructional design provides a systematic process and a framework for analytically planning, developing, and adapting mathematics instruction (Saritas, 2004). "[Instructional design] is an effective way to alleviate many pressing problems in education. Instructional design is a linking science – a body of knowledge that prescribes instructional actions to optimize desired instructional outcomes, such as achievement and effect" (Reigeluth, 1983, p.5).

Instructional design alone cannot produce better learning and achievement. The instructional designer must know crucial factors that affect student learning and build a bridge between goals and student performance. Identifying these factors will help to utilize limited resources including financial resources and time more effectively (Libienski & Gutierrez, 2008).

In an effort to understand the factors associated with mathematics achievement, researchers have focused on many factors. (Beaton & Dwyer, 2002; Kellaghan & Madaus, 2002; Kifer, 2002). The impact of various demographic, social, economical and educational factors on students' math achievement continues to be of great interest to the educators and researchers. For instance, Israel et al. (2001) concluded that parents' socioeconomic status is correlated with a child's educational achievement. Another study by Jensen and Seltzer (2000) showed that factors such as individual study, parents' role, and social environment had a significant influence on "further education" decisions and achievements of young students'. In another study, Meece, Wigfield & Eccles (1990) investigated cognitive motivational variables that influence high school students' decisions to enroll in advanced math courses. Their findings revealed that math ability perceptions affect students' valuing of math and their expectations for achievement.

A growing body of research provides additional factors which could have an impact on students' achievement such as *gender, family structure, parents' educational level, socio-economic status, parent and student attitudes toward school*, and *parent involvement* (Campbell et al. 2000; Epstein, 1991; Fennema & Sherman, 1976, 1986; Fluty, 1997). Three factors or predictors in math achievement, are divided into sub factors: Demographic Factors (gender, socio-economic status, parent's educational level), Instructional Factors (teacher competency, instructional strategies and techniques, curriculum, school context and facilities), and Individual Factors (self-directed learning, arithmetic ability, motivation). These are examined in the literature review below.

Purpose of the Study

A growing body of research findings indicates that demographic, individual and instructional factors have an impact on the mathematical achievement of students. Identifying factors that affect mathematics achievement is particularly important to effectively educate new generations in, what is for many, a difficult subject. It also provides instructional designers better inputs for their design decisions. The purpose of the present study was to find answers to the following research questions:

1. How much do mathematics department students think demographic factors, including gender, parents' educational level and socio-economic status, influence their achievement in mathematics?
2. How much do mathematics department students think instructional factors including curriculum, instructional strategies and methods, teacher competency in math education, and school context and facilities influence mathematic achievement?
3. How much do mathematics department students think individual factors including self-directed learning, arithmetic ability, and motivation or concentration influence mathematic achievement?
4. What are the three most influential factors on the mathematics achievement of students?
5. Is there a difference in the perceived effects of demographic factors among freshmen, sophomores, juniors and seniors?
6. Is there a difference in the perceived effects of instructional factors among freshmen, sophomores, juniors and seniors?
7. Is there a difference in the perceived effects of individual factors among freshmen, sophomores, juniors and seniors?

Demographic Factors

Various demographic factors are known to be related to mathematics achievement. Gender, socio-economic status, and parents' educational level are factors that have been analyzed in this study as predictors of math achievement.

Gender

Many variables have long been studied as predictors of mathematics achievement. However, gender issues on math achievement are studied most frequently by researchers. For instance, a study through a meta-analysis reveals that males tend to do better on mathematics tests that involve problem-solving (Hyde, Fennema, and Lamon 1990). Females tend to do better in computation, and there is no significant gender difference in understanding math concepts. Another study shows that females tend to earn better grades than males in mathematics (Kimball, 1989).

Some recent studies have revealed that gender differences in mathematics education seem to be narrowing in many countries. However, studies indicate that as students reach higher grades, gender differences favor increase in math achievement by males (Campbell, 1995; Gray, 1996; Mullis, Martin, Fierros, Goldberg, & Stemler, 2000). For instance, the results from the Third International Mathematics and Science Study showed that mathematics achievement scores of each gender group were close to each other at the primary and middle school years (Beaton et al., 1996; Mullis et al., 1997). However, in the final year of secondary school, evidence was found for gender differences in mathematics achievement. Another study, which was conducted to analyze factors that affect math achievement of 11th-graders in math classes with an identified gender gap, also showed that males scored higher than females on 11th grade math achievement test, but this difference decreased from 10th grade (Campbell & Beaudry, 1998).

In addition, gender differences in attitudes and perceptions of the usefulness of mathematics for middle school students were found statistically important (Lockheed, Thorpe, Brooks-Gunn, Casserly, and McAloon 1985; Oakes 1990). For example, female students show less interest in mathematics and have negative attitude toward mathematics. It is also reported that girls tend to learn mathematical concepts by means of rules or cooperative activities, while boys have a tendency to be in a competition to master mathematical concepts (Fennema & Peterson, 1985; Hopkins, McGillicuddy-De Lisi, & De Lisi, 1997).

The literature on gender differences provides evidences that gender issues impact achievement in mathematics. Hence, it is crucial for educators and researchers to pay attention to gender differences in the design of mathematics instruction.

Socio-Economic Status

Socio-economic status is determined to be a predictor of mathematics achievement. Studies repeatedly discovered that the parents' annual level of income is correlated with students' math achievement scores (Eamon, 2005; Jeynes, 2002; Hochschild, 2003; McNeal, 2001). Socio-economic status was found significant in primary math and science achievement scores (Ma & Klinger, 2000). Another study found poor academic achievement of Canadian students to be attributable to their low socio-economic status (Hull, 1990). Socio-economic status was examined and found to be one of the four most important predictors of discrepancy in academic achievement of Canadian students (aged 15) in reading, mathematics, and science by the Program for International Student Assessment (Human Resources Development Canada, Statistics Canada, & Council of Ministers of Education Canada, 2001).

A number of studies showed that parents with higher socio-economic status are more involved in their children's education than parents of lower socio-economic status. This greater involvement results in development of positive attitudes of children toward school, classes, and enhancement of academic achievement (Epstein, 1987; Lareau, 1987; Stevenson & Baker, 1987). It is believed that low socio-economic status negatively influences academic achievement, in part, because it prevents students from accessing various educational materials and resources, and creates a distressing atmosphere at home (possible disruptions in parenting or an increased likelihood family conflicts) (Majoribank, 1996; Jeynes, 2002). For these reasons, socio-economic status of a student is a common factor that determines academic achievement.

Parents' Educational Level

Parents' educational level has been shown to be a factor in academic achievement. Parents serve as a role model and a guide in encouraging their children to pursue high educational goals and desires by establishing the educational resources on hand in the home and holding particular attitudes and values towards their children's learning. In this case, the educational attainment of parents serve as an indicator of attitudes and values which parents use to create a home environment that can affect children's learning and achievement.

A number of studies indicated that student achievement is correlated highly with the educational attainment of parents (Coleman, 1966). For instance, students whose parents had less than high school education obtained lower grades in mathematics than those whose parents had higher levels of education (Campbell, Hombo, & Mazzeo, 2000). Research has shown that parents' educational level not only impact student attitudes toward learning but also impact their math achievement scores.

Instructional Factors

Curriculum

Many concerns have been emphasized in the literature about the existing math curricula that emphasize

> *. . . not so much a form of thinking as a substitute for thinking. The process of calculation or computation only involves the deployment of a set routine with no room for ingenuity or flair, no place for guess work or surprise, no chance for discovery, no need for the human being, in fact (Scheffler, 1975, p.184).*

The concerns here are not that students should never learn to compute, but that students must learn how to critically analyze mathematical problems and produce effective solutions. This requires them to learn, how to make sense of complex math concepts and how to think mathematically (Cobb et al., 1992). Many mathematics curricula overemphasize memorization of facts and underemphasize understanding and application of these facts to discover, make connections, and test math concepts. Memorization must be raised to conceptualization, application and problem-solving for students to successfully apply what they learn. An impressive body of research suggests that curriculum that considers students to be incapable of metacognitive actions (e.g., complex reasoning) should be replaced with the one that sees students who are capable of higher-order thinking and reasoning when supported with necessary and relevant knowledge and activities (Bransford et al., 1994; Schauble et al., 1995; Warren & Rosebery, 1996). Research has also revealed evidence that curricula in which students' knowledge and skills grow is significantly connected to their learning, and therefore their achievement (Brown & Campione, 1994; Lehrer & Chazan, 1998).

Instructional Strategies and Methods

Being successful in math involves the ability to understanding one's current state of knowledge, build on it, improve it, and make changes or decisions in the face of conflicts. To do this requires problem solving, abstracting, inventing, and proving (Romberg, 1983). These are fundamental cognitive operations that students need to develop and use it in math classes. Therefore, instructional strategies and methods that provide students with learning situations where they can develop and apply higher-order operations are critical for mathematics achievement.

In the literature, it is pointed out that for students to accomplish learning, teachers should provide meaningful and authentic learning activities to enable students to construct their understanding and knowledge of this subject domain (Wilson, 1996). In addition, it is emphasized that instructional strategies where students actively participate in their own learning is critical for success (Bloom, B. 1976). Instructional strategies shape the progress of students' learning and accomplishment.

Teacher Competency in Math Education

Many studies report that what teachers know and believe about mathematics is directly connected to their instructional choices and procedures (Brophy, 1990; Brown, 1985; National Council of Teachers of Mathematics, 1989; Thompson, 1992; Wilson, 1990a, b). Geliert (1999) also reported that "in mathematics education research, it seems to be undisputed that the teacher's philosophy of mathematics has a significant influence on the structure of mathematics classes" (p. 24). Teachers need to have skills and knowledge to apply their philosophy of teaching and instructional decisions.

In the 21st century, one shifting paradigm in education is about teachers' roles and competencies. Findings from research on teacher competency point out that

If teachers are to prepare an ever more diverse group of students for much more challenging work--for framing problems; finding, integrating and synthesizing information; creating new solutions; learning on their own; and working cooperatively--they will need substantially more knowledge and radically different skills than most now have and most schools of education now develop (Darling-Hammond, 1997, p. 154).

Teachers not only need knowledge of a particular subject matter but also need to have pedagogical knowledge and knowledge of their students (Bransford et al., 2000). Teacher competency in these areas is closely linked to student thinking, understanding and learning in math education. There is no doubt that student achievement in math education requires teachers to have a firm understanding of the subject domain and the epistemology that guides math education (Ball, 1993; Grossman et al., 1989; Rosebery et al., 1992) as well as an equally meticulous understanding of different kinds of instructional activities that promote student achievement. Competent math teachers provide a roadmap to guide students to an organized understanding of mathematical concepts, to reflective learning, to critical thinking, and ultimately to mathematical achievement.

School Context and Facilities

School context and its facilities could be an important factor in student achievement. In fact, identifying factors related to the school environment has become a research focus among educational practitioners. For instance, research suggests that student achievement is associated with a safe and orderly school climate (Reyonds et al., 1996).

Researchers also found a negative impact on student achievement where deficiencies of school features or components such as temperature, lighting, and age exist. In a study by Harner (1974), temperatures above 23° C (74° F) adversely affected mathematics skills. In terms of the condition of school building, Cash (1993) found student achievement scores in standard buildings to be lower than the scores of students in above standard buildings. In addition, Rivera-Batiz and Marti (1995) conducted multiple regression statistical analysis to examine the relationship between overcrowded school buildings and student achievement. The findings indicated that a high population of students had a negative effect on student achievement.

Individual Factors

Self-Directed Learning

Self-directed learning could be a factor in students' math achievement. Mathematics learning requires a deep understanding of mathematical concepts, the ability to make connections between them, and produce effective solutions to ill-structured domains. There is no perfect, well-structured, planned or prescribed system that lets students think and act mathematically. This can be done if, and only if, students play their assigned roles in their learning progress. Self-directed learning has an important place in successful math learning. Self-directed students can take the initiative in their learning by diagnosing their needs, formulating goals, identifying resources for learning, and evaluating or monitoring learning outcomes (Knowles 1975). The teacher's role is to engage students by helping to organize and assist them as they take the initiative in their own self-directed explorations, instead of directing their learning autocratically (Strommen & Lincoln, 1992).

Arithmetic Ability

Arithmetic ability could also be another predictor of math achievement. Arithmetic ability includes the skills such as manipulating mathematical knowledge and concepts in ways that transform their meaning and implications. It allows students to interpret, analyze, synthesize, generalize, or hypothesize the facts and ideas of mathematics. Students with high arithmetic ability or mathematical reasoning can engage in tasks such as solving complex problems, discovering new meanings and understanding, and arriving at logical conclusions.

Arithmetic ability was determined by various studies as a critical factor on students' math achievement. For instance, in a study by Kaeley (1993), arithmetic ability gave the highest correlation coefficient with mathematics achievement. Similarly, student achievement scores were found to be most strongly predicted by level of ability (Schiefele & Csikszentmihalyi, 1995). Some other researchers have also investigated the relationship of gender issues and arithmetic ability on math achievement. For instance, Mills (1997) conducted a study to investigate longitudinal data gathered over 10 years with an aim at asking whether personality traits were related to gender differences in long-term achievement in mathematics and the sciences. The study revealed that math ability was the most significant predictor of long-term achievement in math for young women. However, the level of math ability did not seem to be a factor of long-term math achievement for young men.

Motivation or Concentration

Mathematics education requires highly motivated students because it requires reasoning, making interpretations, and solving problems, mathematical issues, and concepts. The challenges of mathematics learning for today's education is that it requires disciplined study, concentration and motivation. To meet these challenges, learners must be focused and motivated to progress. Broussard and Garrison (2004) examined the relationship between classroom motivation and academic achievement in elementary-school-aged children (122-first grade and 129-third grade participants). Consistent with previous studies, they found that for a higher level of mastery, motivation was related to higher math grades.

The teacher's role in students' motivation to learn should not be underestimated. In helping students become motivated learners and producers of mathematical knowledge successfully, the teacher's main instructional task is to create a learning environment where students can engage in mathematical thinking activities and see mathematics as something requiring "exploration, conjecture, representation, generalization, verification, and reflection" (Carr, 1996, p.58).

Method

Participants

The subjects for the study included 250 undergraduate students enrolled in the mathematics department of a public university located in Turkey. 42.4% of the participants were females, and 57.6% were males. Subjects for the study were retrieved from freshmen, sophomores, juniors and seniors randomly. The distribution of the subjects by the grade level was 70 freshmen, 80 sophomores, 60 juniors and 40 seniors. 94.8% of the participants' age was between the years of 18 and 25, and the rest of them were above 25. Participants enrolled the mathematics department based on their scores on the nationwide university entrance exam.

Instrument

A Likert scale survey was conducted in this study for the data collection. The first part of the survey consisted of three questions (gender, age and grade level) to learn about participants' demographic distribution. For demographic purposes?. The second part of the survey was adapted from Dursun & Dede (2004)'s study to determine the effectiveness of demographic, instructional, and individual factors on students' mathematics achievement. In the second section of the survey instrument, three questions were asked for examining demographic factors, four questions for instructional factors, and three questions for individual factors on students' math achievement. Likert scale items with response categories ranging from "very effective" to "ineffective" were designed for the second part of the survey.

Procedure

The data collection instrument was organized and pilot-tested to obtain reliability. Course calendar was reviewed to identify the most appropriate date and time of participants for the subjects' retrieve. Prospective participants were reached through randomly visits to classes at a mathematics department of a public university. The purpose of the study was explained to mathematics department students, and their voluntary participation was requested. All students in these mathematics classes volunteered to participate in the study. Printed survey instruments were distributed to the students. All students completed and returned survey on the same day.

Analysis

Collected instruments were reviewed for any missing data entry or errors. No missing data or error were detected. Then collected data were imported to the statistical analysis package (SPSS 13) for later analysis. Descriptive analysis, ANOVA and Post Hoc Multiple Comparison LSD test were used to answer the research questions. All statistical analyses were conducted with a significant level of 0.05.

Results

The first research question investigated students' perceptions whether or not demographic factors including gender, parents' educational level, and socio-economic status have an effect on mathematics achievement. Participants' responses were reviewed to identify the most frequently answered response for demographic factors. Most of the participants, 39.6%, indicated that the gender has no effect on students' mathematics achievement. In contrast to the gender, 26.4%, of the participants indicated that parents' educational level, and 31.2% of participants also stated that socio-economic status, were effective factors on the mathematics achievement of students (see Table-1).

Table 1

Effects of Demographic Factors on Students' Mathematic Achievement

	Very Effective		Effective		Less Effective		Ineffective		No Comment	
Demographic Factors	N	%	N	%	N	%	N	%	N	%
Gender	21	8.4	30	12	51	20.4	99	39.6	49	19.6
Parents' Educational Level	40	16	66	26.4	63	25.2	57	22.8	24	9.6
Socio-Economic Status	48	19.2	78	31.2	61	24.4	54	21.6	9	3.6

The second research question investigated mathematics department students' believes on the effectiveness of instructional factors including curriculum, instructional strategies and methods, teacher competency in math education, and school context and facilities on the mathematic achievement. Participants' responses were reviewed to identify the most frequently answered response for instructional factors. Participants indicated that all instructional factors were very effective on the mathematic achievement of students (See Table-2). Among the instructional factors, instructional strategies and methods emerged as the most influential factor on the mathematic achievement of students.

Table 2

Effects of Instructional Factors on Students' Mathematic Achievement

	Very Effective		Effective		Less Effective		Ineffective		No Comment	
Instructional Factors	N	%	N	%	N	%	N	%	N	%
Curriculum	122	48.8	93	37.2	19	7.6	12	4.8	4	1.6
Instructional Strategies and Methods	193	77.8	35	14.1	16	6.4	4	1.6	0	0
Teacher Competency in Math Education	168	67.2	63	25.2	14	5.6	4	1.6	1	0.4
School Context & Facilities	88	35.2	88	35.2	53	21.2	16	6.4	5	2

The third research question investigated mathematic department students believes about the effectiveness of individual factors including self-directed learning, arithmetic ability, and motivation or concentration on the mathematic achievement. Participants' responses were reviewed to identify the most frequently answered response for instructional factors. Participant indicated that they believe all individual factors identified in this study were very effective on the mathematic achievement of students (See Table-3). Motivation or concentration emerged as the most effective factor on the mathematics achievement of students.

Table 3

Effects of Individual Factors on Students' Mathematic Achievement

	Very Effective		Effective		Less Effective		Ineffective		No Comment	
Individual Factors	N	%	N	%	N	%	N	%	N	%
Self-Directed Learning	123	49.2	88	35.2	19	7.6	15	6	5	2
Arithmetic Ability	124	49.6	93	37.2	22	8.8	9	3.6	2	0.8
Motivation or Concentration	180	72	50	20	17	6.8	0	0	3	1.2

The fourth research question investigated mathematic department students believes about the three most influential factors on the mathematic achievement of students. 72% of the participants reported instructional strategies and methods used to teach the mathematic courses as the most influential factor on the mathematic achievement of students. The second most influential factor emerged was the motivation and concentration of students. The teacher competency in math education was reported as the third the most effective factor on the math achievement of students (see Table-4).

Table 4

Factors Affecting the Mathematics Achievement

	Very Effective		Effective		Less Effective		Ineffective		No Comment	
Demographic Factors	N	%	N	%	N	%	N	%	N	%
Gender	21	8.4	30	12	51	20.4	99	39.6	49	19.6
Parents' Educational Level	40	16	66	26.4	63	25.2	57	22.8	24	9.6
Socio-Economic Status	48	19.2	78	31.2	61	24.4	54	21.6	9	3.6

Instructional Factors										
Curriculum	122	48.8	93	37.2	19	7.6	12	4.8	4	1.6
Instructional Strategies and Methods	193	77.8	35	14.1	16	6.4	4	1.6	0	0
Teacher Competency in Math Education	168	67.2	63	25.2	14	5.6	4	1.6	1	0.4
School Context & Facilities	88	35.2	88	35.2	53	21.2	16	6.4	5	2
Individual Factors										
Self-Directed Learning	123	49.2	88	35.2	19	7.6	15	6	5	2
Arithmetic Ability	124	49.6	93	37.2	22	8.8	9	3.6	2	0.8
Motivation or Concentration	180	72	50	20	17	6.8	0	0	3	1.2

The fifth question investigated whether there was a difference in the perceived effects of demographic factors among freshmen, sophomores, juniors and seniors. Freshmen, sophomores, juniors, and seniors students' responses for the demographic factors were compared using Analysis of Variance (ANOVA). Results of the One-Way ANOVA for three demographic factors revealed that gender and parents' educational level were not stated as a significant factor on the mathematic achievement of students. However, differences among freshmen, sophomore, junior and senior students' thoughts for the effects of socio-economic status on the mathematic achievement of students were found (see Table-5).

Table-5

Comparison of Demographic Factors Affecting the Mathematics Achievement

		Sum of Squares	Df	Mean Square	F	Sig.
Gender	Between Groups	2.148	3	.716	.513	.674
	Within Groups	342.093	245	1.39		
	Total	344.241	248			
Parents' Educational Level	Between Groups	1.667	3	.556	.367	.777
	Within Groups	370.582	245	1.51		
	Total	372.249	248			
Socio Economic Status	Between Groups	45.838	3	15.279	13.7	.000*
	Within Groups	272.379	245	1.112		
	Total	318.217	248			

In order to identify where the differences were, Post Hoc Multiple Comparison LSD (Least Significant Difference t-test) was conducted. Results of the test revealed that except for the senior and sophomore students' opinions, differences were found among other student groups' opinions (see Table-6).

Table-6

Post Hoc Multiple Comparison LSD for the Socio-Economic Status

(I) Grade Level	(J) Grade Level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	

					Lower Bound	Upper Bound
Freshman	Sophomore	-.71429(*)	.17257	.000	-1.0542	-.3744
	Junior	-1.16429(*)	.18550	.000	-1.5297	-.7989
	Senior	-.72711(*)	.21069	.001	-1.1421	-.3121
Sophomore	Freshman	.71429(*)	.17257	.000	.3744	1.0542
	Junior	-.45000(*)	.18007	.013	-.8047	-.0953
	Senior	-.01282	.20592	.950	-.4184	.3928
Junior	Freshman	1.16429(*)	.18550	.000	.7989	1.5297
	Sophomore	.45000(*)	.18007	.013	.0953	.8047
	Senior	.43718(*)	.21688	.045	.0100	.8644
Senior	Freshman	.72711(*)	.21069	.001	.3121	1.1421
	Sophomore	.01282	.20592	.950	-.3928	.4184
	Junior	-.43718(*)	.21688	.045	-.8644	-.0100

* The mean difference is significant at the .05 level.

The sixth research question investigated whether there was a difference in the perceived effects of instructional factors among freshmen, sophomores, juniors and seniors. Freshmen, sophomores, juniors, and seniors students' responses for the instructional factors were compared using Analysis of Variance (ANOVA). Results of the One-Way ANOVA for four instructional factors revealed that only school context and facilities was a significant factor on the mathematic achievement of students (see Table-7).

Table-7

Comparison of Instructional Factors Affecting the Mathematics Achievement

		Sum of Squares	df	Mean Square	F	Sig.
Curriculum	Between Groups	.303	3	.101	.199	.897
	Within Groups	124.71	245	.509		
	Total	125.02	248			
Instructional Strategies Methods	Between Groups	1.463	3	.488	1.098	.351
	Within Groups	108.83	245	.444		
	Total	110.29	248			
Teacher Competencies	Between Groups	7.117	3	2.372	2.399	.069
	Within Groups	242.30	245	.989		
	Total	249.42	248			
School Context Facilities	Between Groups	6.640	3	2.213	2.713	.046
	Within Groups	199.86	245	.816		
	Total	206.50	248			

Post Hoc Multiple Comparison LSD (Least Significant Difference t-test) was conducted to identify where the differences were. Results of the test revealed that only senior-freshman and senior-junior students' opinions were statistically different for the effect of school context and facilities on the mathematic achievement of students (see Table-8).

The seventh research question investigated whether there was a difference in the perceived effects of individual factors among freshmen, sophomore, junior and senior students. Freshmen, sophomores, juniors, and seniors students' responses for the individual factors were compared using Analysis of Variance (ANOVA). Results of the One-Way ANOVA for three individual factors revealed that none of the factors was different among freshmen, sophomores, juniors and seniors (see Table-9).

Table-8

Post Hoc Multiple Comparison LSD for the School Context and Facilities

(I) GradeLevel	(J) GradeLevel	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Freshman	Sophomore	.0892	.14782	.546	-.2019	.3804
	Junior	-.1523	.1589	.33	-.465	.160
	Senior	.36557(*)	.18048	.044	.0101	.7210
Sophomore	Freshman	-.08929	.14782	.546	-.3804	.2019
	Junior	-.24167	.15425	.118	-.5455	.0622
	Senior	.27628	.17639	.119	-.0712	.6237
Junior	Freshman	.15238	.15890	.339	-.1606	.4654
	Sophomore	.24167	.15425	.118	-.0622	.5455
	Senior	.51795(*)	.18578	.006	.1520	.8839
Senior	Freshman	-.36557(*)	.18048	.044	-.7210	-.0101
	Sophomore	-.27628	.17639	.119	-.6237	.0712
	Junior	-.51795(*)	.18578	.006	-.8839	-.1520

* The mean difference is significant at the .05 level.

Table-9

Comparison of Individual Factors Affecting the Mathematics Achievement

		Sum of Squares	df	Mean Square	F	Sig.
Self-Directed Learning	Between Groups	1.856	3	.619	.670	.571
	Within Groups	226.200	245	.923		
	Total	228.056	248			
Arithmetic Ability	Between Groups	2.531	3	.844	1.63	.182
	Within Groups	126.457	245	.516		
	Total	128.988	248			
Motivation or Concentration	Between Groups	1.430	3	.477	.672	.570
	Within Groups	173.759	245	.709		
	Total	175.189	248			

Discussion and Conclusion

Instructional design is a challenging procedure requiring the consideration of all elements of the learning to bring about the desired change (Colakoglu, & Akdemir, 2008). It is accepted that changing the quality of teaching and learning mathematics in positive direction is one of the major challenges and concerns of educators and instructional designers. They ought to seek innovative and alternative ways to meet the evolving demands and needs of students in mathematics education. Identifying the factors that possibly affect the mathematics achievements of students could help instructional designers and instructors to select the best instructional strategies to design the most effective and efficient instruction. Existing studies suggested many variables that can have effects on the math achievement of students. Opinions of mathematics department students were collected in this study to identify the factors affecting achievement of students in math courses. Also opinions of freshman, sophomore, junior and senior students in the math department were compared in this study.

Effects of demographic factors including gender, parents' education level and socio-economic status on math achievement were investigated. In contrast to other studies (Campbell, 1995; Gray, 1996; Kimball, 1989), gender was not found an important factor influencing the math achievement of students. Similar results were found by Beaton et al., (1996) and Mullis et al., (1997). Parents' education level was found to be an effective factor in achievement of students in math courses similar to the results of Coleman, (1966) and Campbell, Hombo, & Mazzeo, (2000). Parents with higher level of education could be a role model for their children to accomplish high levels of achievement in math courses. Similar to the Eamon, (2005); Jeynes, (2002); Hochschild, (2003) and McNeal, (2001), socio-economic status in this study was reported as an important factor affecting the math achievement of students in math courses. Parents with high income seem to provide richer instructional resources to their children which may eventually help to improve the math scores of students. Significant differences were found for the effects of socio-economic status among freshman, sophomore, junior and senior students. As the grade level increases, math students' opinions about the effects of socio-economic status on the math achievement increases. This finding illustrates that math students need more financial resources as they get close to graduate in math department. Deficiency of financial resources is reported as a factor that has an effect on their math achievement.

In terms of demographic factors, the findings revealed that parents' education level and socio-economic status were two vital factors for math achievement. These are the factors that instructional designers should not ignore since they are important for math achievement. Students from different socio-economic strata with different levels of parent education may exhibit very different attitudes, needs, and other characteristics for learning and studying mathematics. Thus, achievement of those students in math courses depends on instructional design that can successfully transmit crucial mathematical skills and knowledge to students from different backgrounds.

Significant factors in math instruction and student achievement include curriculum, instructional strategies, methods, teacher (math) competency, school context and facilities. The mathematics curriculum contains specific subject-matter and instructional design principles to enable students to develop logical and mathematical skills needed to understand fundamental mathematical concepts. In other words, designing an instruction based on a curriculum that is in harmony with instructional design can scaffold student learning and promote their achievement in mathematics. Instructional strategies and methods are important for the achievement of students. The literature suggests that learning situations ought to be selected and implemented in a way that allows students to apply higher order operations (Wilson, 1996). Another important factor math achievement is teacher competency. Similar studies reported that teachers should have good understanding of subject domain to improve the math achievement of students (Ball, 1993; Grossman, et. al., 1989; Rosebery et. al., 1992). School context and facilities are also reported to influence math achievement in this study. School safety and facilities (Reyonds et. al., 1996), temperature of the class (Harner, 1974), features of the school buildings (Cash, 1993), and crowdedness of school (Rivera-Batiz and Marti, 1995) were also reported to influence the achievement of students. Collectively, these results point out that attention should be given to school context and facilities to improve the math achievement of students.

Knowing and understanding the opinions of math students is important to identify factors they perceive to be effective for achievement in mathematics. Findings of this study revealed three factors that contribute to mathematics achievement: instructional strategies and methods, teacher competency in math education, and motivation or concentration. Further investigation of these three factors, through experimental studies, should enable instructional designers and math educators to continue to improve mathematics instruction.

This study reported that instructional design of a mathematics course is important and should be compatible to the factors identified for mathematics achievement. Educators need to adapt and create alternative innovative learning and teaching strategies for effective mathematics education. The findings also suggest that different instructional design strategies should be studied and applied in different contexts. Experiment with new instructional design models in a variety of different circumstances is vital to optimize mathematics instruction. One-size-fits-all instructional design strategies are not as efficient as those that are customized to meet specific learner needs. It is important to embody diagnostic and prescriptive tools to determine the best-fit design for each individual learner, and to make learning more meaningful based on known critical factors that affect mathematics achievement.

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