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Learning styles affecting student learning in online based education systems

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LEARNING STYLES AFFECTING STUDENT LEARNING IN ONLINE BASED EDUCATION SYSTEMS

By

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In the last few decades various learning theories emerged characterizing the strengths and preferences people have in the ways they assimilate and process new ideas and concepts. In this capstone we introduce the results of an exploratory pilot study which examines how learning styles or multiple intelligences influence performance in students who used an online homework system in their pre-service teacher math content courses at CSUMB. There is literature concerning whether it is important for educators to be able to adapt their teaching to adjust to their students' multiple learning styles. This study will be able to provide guidance towards the future research in the use of on-line homework in California State University Monterey Bay's MATH 308 - Elementary Math from an Advanced Viewpoint A (Math for Elementary School Teachers), and MATH 309 - Elementary Math from an Advanced Viewpoint B classes (n=18). Information regarding students' multiple intelligence/learning styles and their performance in online homework and course grades was gathered and analyzed. Preliminary analysis indicates that further study should focus on analyzing trends among students who exhibit the following multiple intelligences: visual, musical, kinesthetic, intrapersonal, naturalist, and linguistic. Also further study should focus on active vs. reflective learners, and sensing vs. intuitive learning styles.

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1. Introduction

Overview

As college campuses move forward in the way they are educating students and attempting to cater to individual needs, the importance of having on-line learning systems is growing. The importance of technology can be seen in the *Standards* (NCTM 1989, 1991) for school mathematics. Verbych (2005) suggested that an "effort should be made to identify students' approach to learning". Part of this process is understanding how that student approaches learning and then determine how they are learning.

Another aspect of current instruction is how we are educating the future teachers. The current No Child Left Behind (NCLB) legislation has created a standards-based hierarchical accountability system extending from the federal level to the individual level of teacher, student and parent. With 150 pre-service teachers enrolled in the Mathematics Department every semester, the need to keep teachers at the level of the NCLB standards needs to begin with the education they receive prior to credential program enrollment. "On March 2, 2006 the California State University Chancellor's Office sponsored the California State University Math and Science Teacher Summit to address this issue by recruiting and training highly qualified math and science teachers" (Scott 2006a). The shortage of competent math teachers is not only felt across nationwide, but also at CSUMB as well. One only needs to look in the math department and see flyers all around advertising scholarships for future teachers in math, science, and special education. In President Bush's 2006 State of the Union address, he proposed the American Competitiveness Initiative which calls for $380 million to train 70,000 teachers for advanced math and science courses and recruit 30,000 industry professionals to become adjunct teachers (Bush 2006).

This research is a pilot of how students learn using an online homework system used by pre-service teacher in mathematics courses at CSUMB. The online homework focuses on procedural or computational aspects of the material leaving more time conceptual course material in the traditional homework component of the course. In particular, in this study we consider how students' learning styles affect what they learning using the system and what aspects of the systems correlate to student learning.

Learning style can be defined as the way in which a student prefers to do things that relate to learning. These are the different ways that people perceive, process, and learn information. Dunn (1984) notes that a learning style is the way in which information is absorbed and retained, that is, it describes not 'what' the student learns but 'how' the student learns. One issue that is currently being examined with respect to learning styles is gender differences. Brew (2002) and Keri (2002) have both shown differences between males and females. Keri (2002) shows that females have a preference for concrete experiences and males have a preference for abstract conceptualization.

A starting point for this study is a Master's Thesis from Kansas State University that examined the conceptual understanding of students using online homework. Verbych classified students from an online homework based trigonometry class into three groups based on course grades and interviews. The three groups were: (1) students who tried to understand the material conceptually, (2) students who perceive math as a series of procedures to be mastered, and (3) students who just complete what is assigned. Verbych determined that students who were understanding the material conceptually were able to complete the class more successfully.

Following Verbych's thesis, the purpose of this pilot study is to determine if or how multiple intelligence and learning styles affect online mathematical learning at CSUMB and to provide an initial analysis of online mathematical learning. This will assist in the gathering of information for future studies on overall online mathematical learning at CSUMB especially by using students from the MATH 308 - Elementary Math from an Advanced Viewpoint A and MATH 309 - Elementary Math from an Advanced Viewpoint B classes. These classes are math courses for elementary school teachers and have an online homework system. This study attempts to replicate parts of Verbych's findings and is designed to determine how multiple intelligences and styles affect student learning in online homework environments. By using information regarding a student's performance in online homework systems and comparing that to their exam performance, we can attempt to correlate the data to their strong multiple intelligences and learning styles, and identify trends.

Research Objectives

The purpose of the exploratory pilot study was:

- To analyze the student data from the online homework and course grade data (exams, written homework, etc.);
- To determine variables affecting student understanding or performance;
- To determine which features of the online homework system are suitable to students with different multiple intelligences and learning styles.

2. Background

Gardner's Multiple Intelligence Theory

Multiple Intelligences (MI) is based on the premise that there is not just one kind of intelligence. MI suggests that individuals have varied skills and gifts and as a result each person has a profile of intelligences, which includes: linguistic, logical, visual, musical, kinesthetic, interpersonal, intrapersonal, naturalistic, and existential. Each individual possesses all intelligences, can develop each of the intelligences to an acceptable proficiency, and can exhibit an intelligence in different ways (Armstrong 1994). Gardner defines intelligence as, "the biological potential to process information in certain ways that can be activated in a cultural setting to solve problems or make products that are valued in a culture" (Gardner 1993; 1999).

Thus far Gardner has identified nine intelligences. He speculates that there may be many more yet to be identified. These are the paths to student's learning teachers can address in their classrooms right now. They are:

VISUAL/SPATIAL - (Armstrong 1994; Gardner 1983; 1998) students who learn best visually and organize things spatially. They like to see what you are talking about in order to understand. They enjoy charts, graphs, maps, tables, illustrations, art, puzzles, costumes - anything eye catching.

VERBAL/LINGUISTIC - (Armstrong 1994; Gardner 1983; 1998) students who demonstrate strength in the language arts: speaking, writing, reading, listening. These individuals have always been successful in traditional classrooms because their intelligence lends itself to traditional teaching.

MATHEMATICAL/LOGICAL - (Armstrong 1994; Gardner 1983; 1998) students who display an aptitude for numbers, reasoning and problem solving. This is the other type of indivdual who typically does well in traditional classrooms where teaching is logically sequenced and students are asked to conform.

BODILY/KINESTHETIC - (Armstrong 1994; Gardner 1983; 1998) students who experience learning best through activity: games, movement, hands-on tasks, building. These students were often labeled "overly active" in traditional classrooms where they were told to sit and be still!

MUSICAL/RHYTHMIC - (Armstrong 1994; Gardner 1983; 1998) students who learn well through songs, patterns, rhythms, instruments and musical expression. It is easy to overlook a student with this intelligence in traditional education.

INTRAPERSONAL - (Armstrong 1994; Gardner 1983; 1998) students who are especially in touch with their own feelings, values and ideas. They may tend to be more reserved, but they are actually quite intuitive about what they learn and how it relates to them.

INTERPERSONAL - (Armstrong 1994; Gardner 1983; 1998) students who are noticeably people oriented and outgoing, and do their learning cooperatively in groups or with a partner. These individuals may have typically been identified as "talkative" or " too concerned about being social" in a traditional setting.

NATURALIST – (added in 1995; Gardner 1998; 2003) students who love the outdoors, animals, field trips. More than this, though, these students love to pick up on subtle differences in meanings. The traditional classroom has not been accommodating to these individuals.

EXISTENTIALIST – (added in 1994-1995) students who learn in the context of where humankind stands in the "big picture" of existence. They ask "Why are we here?" and "What is our role in the world?" This intelligence is seen in the discipline of philosophy.

Felder and Soloman's Theory

Learning styles can be generally described as "an individual's preferred approach to organizing and presenting information" (Riding & Rayner 1998); "the way in which learners perceive, process, store and recall attempts of learning" (James & Gardner 1995); "distinctive behaviors which serve as indicators of how a person learns from and adapts to his environments, and provide clues as to how a person's mind operates" (Gregoric 1979). Richard Felder and Linda Silverman created a learning style model in 1988 (Felder and Spurlin 2005). This model was developed to determine differences amongst engineering students (Felder and Spurlin 2005). This model suggests that students have a tendency to prefer one dimension as opposed to another. This doesn't mean that a student lacks one dimension. Felder and Silverman suggested four sets of dimensions: active and reflective; sensing and intuitive; visual and verbal; sequential and global.

SENSING AND INTUITIVE – "Sensing involves observing, gathering data through the senses; intuition involves indirect perception by way of the subconscious— accessing memory, speculating, imagining" (Felder and Henriques 1995).

VISUAL AND VERBAL - Just as in Gardner's theory, Felder examines these dimensions as being opposites. Visual learners prefer that information be presented visually rather than in spoken or written words that verbal learners prefer (Felder and Henriques 1995).

ACTIVE AND REFLECTIVE - Felder classifies these learners by a grouping developed by Kolb (1984). "Active processing involves doing something in the external world with the information—discussing it or explaining it or testing it in some way—and reflective processing involves examining and manipulating the information introspectively" (Felder and Henriques 1995).

SEQUENTIAL AND GLOBAL – "Sequential learners absorb information and acquire understanding of material in small connected chunks, and global learners take in information in seemingly unconnected fragments and achieve understanding in large holistic leaps. Before global learners can master the details of a subject they need to understand how the material being presented relates to their prior knowledge and experience, a perspective that relatively few instructors routinely provide" (Felder and Henriques 1995).

Literature Review Specific to Pilot Study

Learning styles can be utilized to enhance students' learning, retention, and retrieval (Federico 2000). Therefore, understanding the effects of learning styles in online environments have the potential to improve planning, producing, and implemention of online educational experiences. While individual learning styles cannot simply be extracted, rather they require psychological testing, and exploration shows that many researchers concur that mixing instruction with learning styles can provide increases in the effectiveness and efficiency of learning (Brusilovsky 2001). However, most collection of this information, especially in web-based educational systems, is gathered by student reported evaluations on questionnaires (Vincent & Ross 2001).

While this study will not analyze for procedural fluency or conceptual understanding, these are two terms that are important to mathematics teaching. Procedural fluency is defined as "skill in carrying out procedures flexibly, accurately, efficiently, and appropriately" (National Research Council 2001). Conceptual understanding is the "comprehension of mathematical concepts, operation, and relations" (National Research Council 2001). In the MATH 308/309 courses, an example of procedural fluency a person who could compute the area and perimeter of a two-dimensional shape while a person with conceptual understanding would be able to explain how to derive the formulas for the area and perimeter of the shape and why the formulas work. These classes use journal assignments to assess students' conceptual understanding. A typical journal assignment question will ask the student explain or derive a formula or method. For example, the following is a journal assignment question on area and perimeter:

> Many people think that if you want to find the area of an irregularly shaped object (like a footprint) you could measure the perimeter by putting string around it, then reshape the piece

of string into a regularly shaped object (like a square), and then find the area based on the measure of the sides. Will this method work? Why or why not?

The online homework system is better suited to assess students' procedural fluency and ability to complete problems.

What is online homework?

California State University Monterey Bay (CSUMB) relies on its students to have the ability to use technology that classes can use on a regular basis. There is a University Learning Requirement (ULR) for technology that states "Students must demonstrate comfort with technology and information search and discovery methods" (CSUMB Catalog 2006). The implementation of the technology can be seen in the Mathematics and Statistics Department. The department uses various programs designed to assist students in achieving learning outcomes. In the MATH 308 and MATH 309 classes, online homework is used in addition to hand-written homework (Scott 2006b).

Fall 2005 marked the beginning of this transition for the department when the MATH 308 homework was brought online. In Spring 2006 online homework was first implemented in MATH 309 and MATH 130-Precalculus classes. Furthermore, online homework will continue to expand with implementations in MATH 150/151-Calculus I/II and STAT 200-Elementary Statistics classes for Fall 2006 and eventually for MATH 98/99-Mathematics Review I/II and MATH 100-Quantitative Literacy. The online system allows student an additional, and instant, assessment tool while not significantly increasing instructor workload.

There are various problems for each of the homework sets. Each class has a different number of sets to complete in a semester. Assignment numbers correspond to the week in the school semester the homework was assigned.

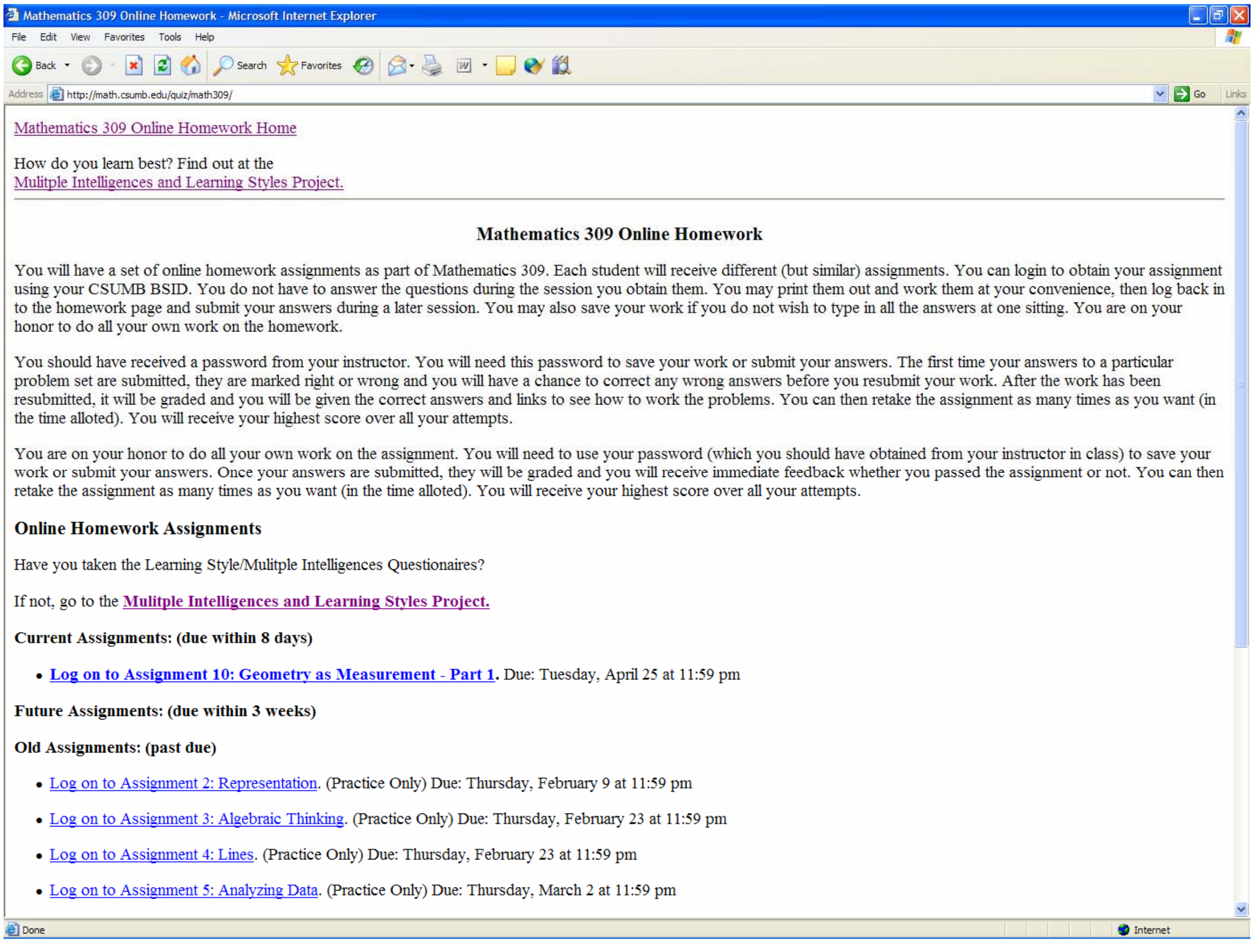
Table 1. MATH 308 homework assignments and the number of problems in each assignment. The assignment number correspond to the week in the school semester the homework was assigned.

Assignment Number	Topic	Number of Questions
1	Number Systems	10
2	Place Value - Base Ten and Other Bases	5
3	Place Value - Extending to Decimals	4
4	Place Value - Extending to Decimals	7
5	Addition/Subtraction - Meanings and Models	5
6	None	N/A
7	Multiplication/Division - Meanings and Models	3
8	Fractions - Meanings and Models	4
9	None	N/A
10	Equivalent Fractions, including decimals, percents, and ratios	5
11	Operations on Fractions - Addition and Subtraction	5
12	Operations on Fractions	6
13	Number Theory	

Table 2. MATH 309 homework assignments and the number of problems in each assignment. The assignment number correspond to the week in the school semester the homework was assigned.

Assignment Number	Topic	Number of Questions
1	None	N/A
2	Representation	5
3	Algebraic Thinking	4
4	Lines	6
5	Analyzing Data	8
6	Concepts Related to Chance	4
7	Geometry as Shape: Basic Ideas	4
8	Geometry as Shape: Two-Dimensional Figures	5
9	Geometry as Transforming Shape: Similarity	4
10	Geometry as Measurement - Part 1 (Area)	5
11	Geometry as Measurement - Part 2 (Area and Perimeter)	
12	Geometry as Measurement - Part 3 (Volume)	

Students go to the class' online homework web-page to select the homework assignment and must login with their CSUMB Banner Student Identification Number (BSID). The start of each homework shows the general directions that are common to every assignment.


Mathematics 309 Online Homework - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://math.csumb.edu/quiz/math309/

Mathematics 309 Online Homework Home

How do you learn best? Find out at the
Mulitple Intelligences and Learning Styles Project.

Mathematics 309 Online Homework

You will have a set of online homework assignments as part of Mathematics 309. Each student will receive different (but similar) assignments. You can login to obtain your assignment using your CSUMB BSID. You do not have to answer the questions during the session you obtain them. You may print them out and work them at your convenience, then log back in to the homework page and submit your answers during a later session. You may also save your work if you do not wish to type in all the answers at one sitting. You are on your honor to do all your own work on the homework.

You should have received a password from your instructor. You will need this password to save your work or submit your answers. The first time your answers to a particular problem set are submitted, they are marked right or wrong and you will have a chance to correct any wrong answers before you resubmit your work. After the work has been resubmitted, it will be graded and you will be given the correct answers and links to see how to work the problems. You can then retake the assignment as many times as you want (in the time alloted). You will receive your highest score over all your attempts.

You are on your honor to do all your own work on the assignment. You will need to use your password (which you should have obtained from your instructor in class) to save your work or submit your answers. Once your answers are submitted, they will be graded and you will receive immediate feedback whether you passed the assignment or not. You can then retake the assignment as many times as you want (in the time alloted). You will receive your highest score over all your attempts.

Online Homework Assignments

Have you taken the Learning Style/Mulitple Intelligences Questionaires?

If not, go to the **Mulitple Intelligences and Learning Styles Project.**

Current Assignments: (due within 8 days)

- **Log on to Assignment 10: Geometry as Measurement - Part 1.** Due: Tuesday, April 25 at 11:59 pm

Future Assignments: (due within 3 weeks)

Old Assignments: (past due)

- Log on to Assignment 2: Representation. (Practice Only) Due: Thursday, February 9 at 11:59 pm
- Log on to Assignment 3: Algebraic Thinking. (Practice Only) Due: Thursday, February 23 at 11:59 pm
- Log on to Assignment 4: Lines. (Practice Only) Due: Thursday, February 23 at 11:59 pm
- Log on to Assignment 5: Analyzing Data. (Practice Only) Due: Thursday, March 2 at 11:59 pm

Done Internet

Figure 1. Example of online homework homepage from the MATH 309 class.

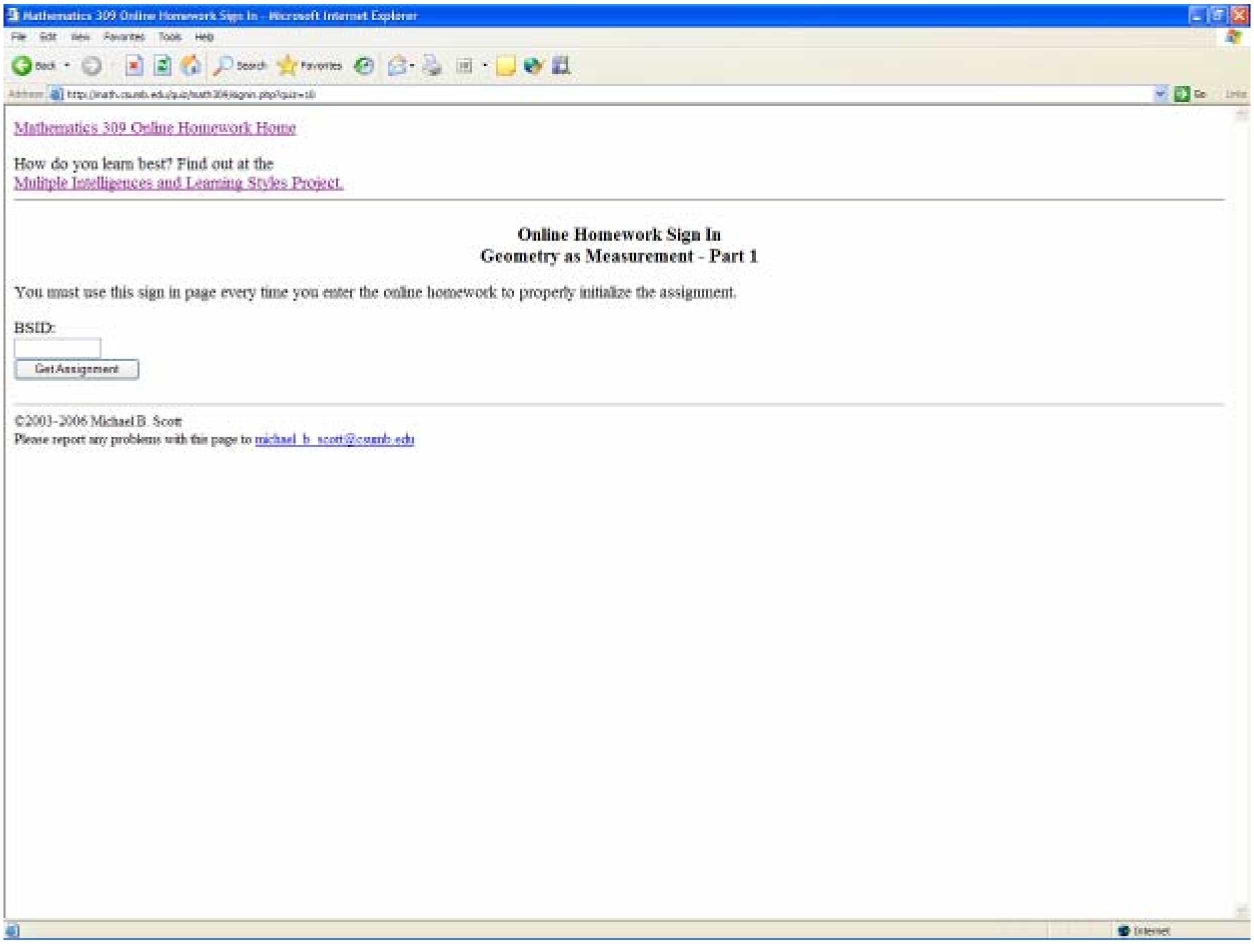


Figure 2. Example of login page from the MATH 309 online homework.

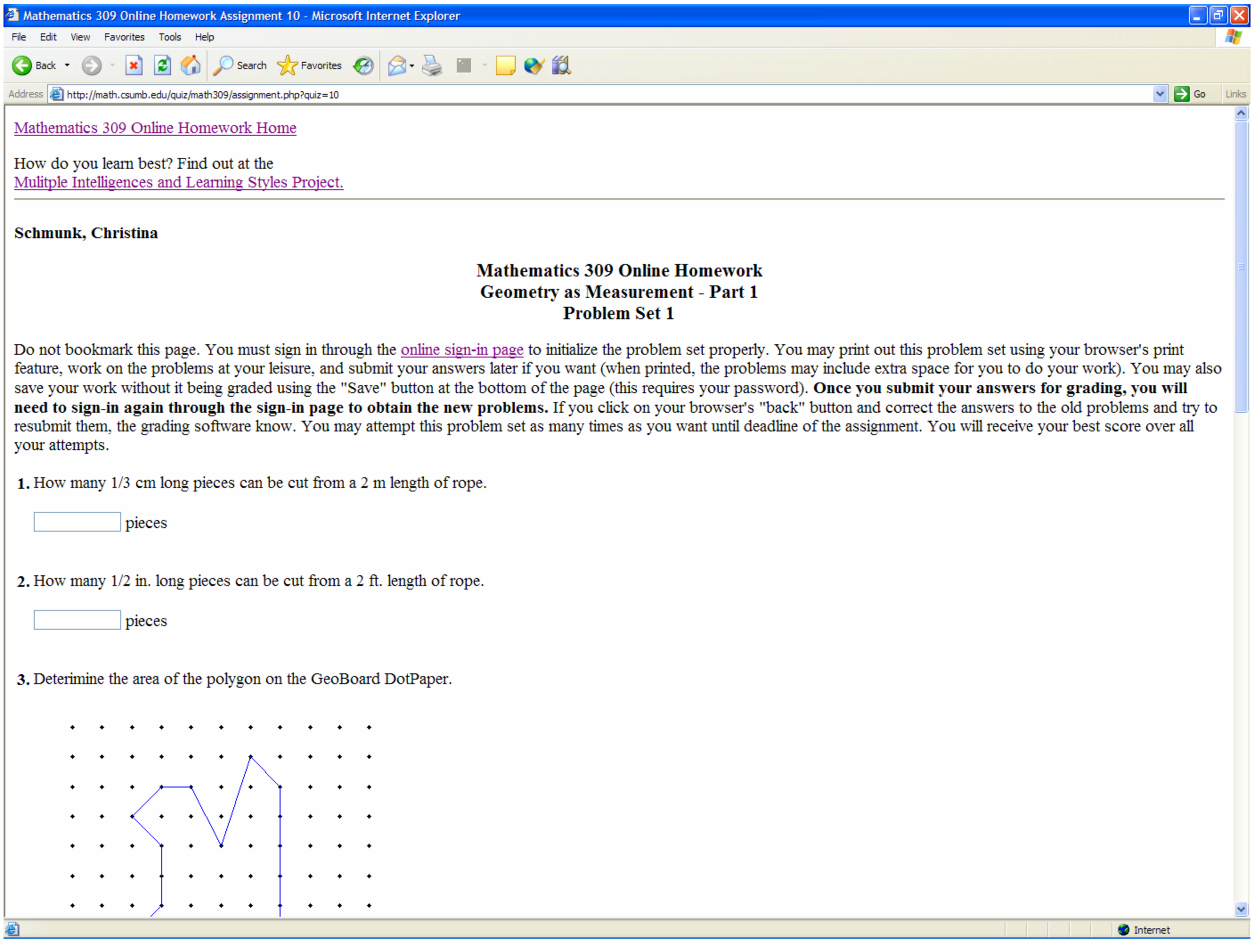


Figure 3. Example of a homework assignment and the general directions that are present at the start of each assignment. This example is MATH 309's homework assignment number 10.

The system runs on the CSUMB web server and constructed using PHP, Java programming languages and a MySQL database server. Any student with internet access can use the system and requires no special software other than a web browser installed with Java. The advantages of this type of system are: a) the instant formative feedback as compared to written assignments, b) the student can take the assignment as many times as needed up to the deadline, c) there is detailed help for each question, and d) the different but similar problems for each student and each attempt. The two-step grading process allows students to have the opportunity to fix their mistakes before the final deadline, receive immediate feedback by being able to view detailed solutions of any problems they missed, and the opportunity to complete the homework multiple times before the assignment's deadline. “For each attempt on an assignment, a student gets one chance to fix any wrong answers. This motivates the students to spend time investigating how they worked missed problems, and to figure out what they did wrong” (Scott 2006a).

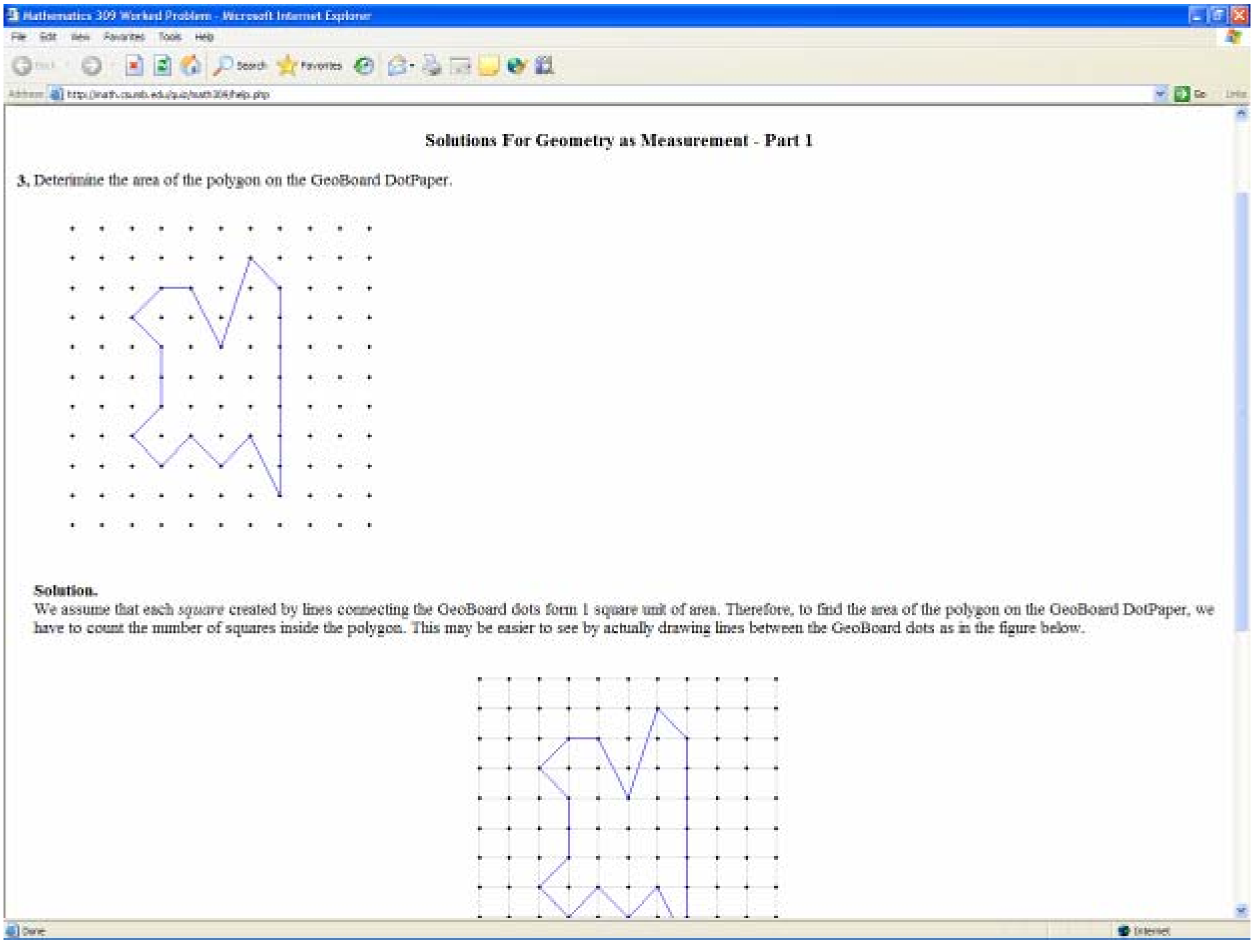


Figure 4. Example of partial detailed solution available to students who missed problems. This example is from MATH 309's homework assignment number 10.

Upon login, students are able to work on the questions immediately or print the set of problems and work on them later. This allows students to use various resources at their disposal, including but not limited to instructors, Instructional Student Assistants (Teacher's Assistants) in Open Lab environments, and Academic Skills Achievement Program (ASAP) a free peer tutoring service available for all students. Students are also able to save their work at any point and return to complete the work at a later time. "Students may attempt each assignment as many times as they would like before it is due. The program generates similar, but different, problems for each attempt of an assignment and for each student. These tutorials directly correspond to and reinforce the methods covered by the instructor and the textbook." (Scott 2006a) When the student has completed all the questions, they must submit the assignment for grading by entering a password. A downside to this system is that it is not able to examine how a student processes or thinks about a problem (it cannot read explanations). It examines and grades a student's procedural fluency.

3. Methodology

Human Subjects Review

An Application was approved in March 2006 by the California State University Monterey Bay Committee for the Protection of Human Subjects to use human research participants in the project titled "Learning Styles Affecting Student Learning in On-Line Based Education Systems."

The Measure

Two measures were used in this study: the Multiple Intelligences Checklist for Adults (MICA; McGrath and Noble 2005) and the Index of Learning Styles Questionnaire (ILS; Felder and Solomon 1991). The MICA is a self-reporting checklist developed for adults and senior secondary students in which participants are asked to respond to a series of items reflecting Gardner's eight intelligences (minus existentialist). The questions were modified and adapted from this questionnaire. Responses are recorded across a four-point scale from Very True of Me to Not True of Me. Totals of selected responses are then compiled into corresponding intelligence to indicate intelligence strengths relative to each other. The MICA has been shown to have "reasonable reliability at the subscale level, e.g. a range from 0.62 to 0.81" (Perry & Ball, unpublished data as cited in Perry & Ball 2004).

The ILS is a questionnaire available on-line asking 44 questions. It assesses students based on four sets of dimensions. Reponses are recorded as which answer applies to the student more frequently. The responses are then totaled into a table separating out the learning styles, then by subtracting the greater sum within each dimension. This total gives students their learning style based on a linear scale. The validity and reliability of this test are explained in Felder and Spurlin (2005).

In order to determine final grades for the MATH 308 students, the information was extracted from Brio, a unified campus reporting environment that allows for departments to gather data for internal campus reports.

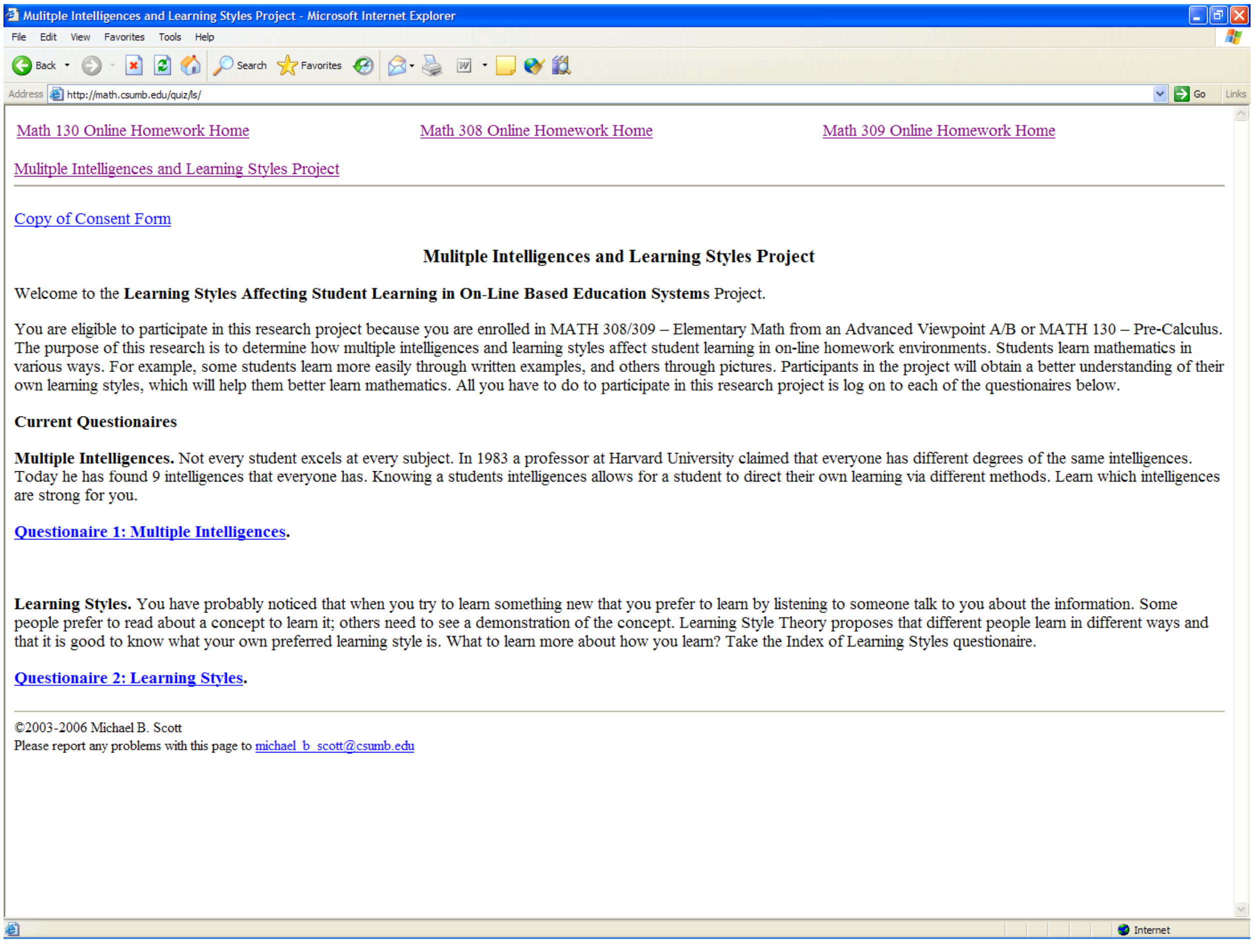


Figure 5. The Multiple Intelligences and Learning Styles homepage.

The Sample Cohort

There were 45 students eligible to participate in this study because they had completed the MATH 308 course in Fall 2005 and the MATH 309 course in Spring 2006. These students were selected because of the limited amount of time the online homework has been operating and their selection allows us to examine students who have used the system more than once. One major factor that needs to be kept in mind with this study is that these courses are mandatory mathematics content for students pursuing a B.A. in Liberal Studies on the teaching pathway. This makes the participants different from traditional mathematics students because they are upper division undergraduate students who should have completed (and passed) the Quantitative Literacy requirement and, in general, recognize that the mathematical content they're learning is relevant to their future career in teaching. Both classes require the online homework with corresponding journal assignments. The journal assignments are set-up to examine how the future teachers present and think about problems while the online assignments are used to test their ability to solve problems.

The subjects included 18 undergraduate students who registered for the MATH 308 course in the Fall 2005 and registered for the MATH 309 course in the Spring 2006 semesters. All students have reported their major to be Liberal Studies and 10 of these students took both the MI questionnaire and the ILS questionnaire, while eight did not complete the ILS questionnaire.

Procedures

The data was extracted from the database and put into a table containing the following columns: class section number, student identification number, highest scores recorded for each of the online homework assignments, time stamps recording the initial login, first attempt, and last attempt, the number of attempts for each of the assignments, the total attempts and scores for the semester, and the course grade. This information was combined with the information gathered by the multiple intelligence and learning styles questionnaires and the 308 course grades gathered from Brio.

Data Analysis

A principal component analysis was conducted to first look for correlations between all variables. A multiple regression was then used to examine the relationship between variables. The utilized model was:

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots + \beta_p x_{pi} + \varepsilon_i, \; i=1, \ldots, n$$

where y = the final 308 course grade

n = the sample size (18 students)

p = the number of independent variables (24)

x = the variables tested

β_0 = a constant representing the y value when x is zero – the y intercept

β_p = a constant representing the slope of the regression line – the change in y for a unit change in x

ε_{ij} = the random variation associated with the productivity of each worker

Statistical Package

All analyses were conducted using the Statistical Package for the Social Sciences (SPSS 13.0 for Windows). Initially a Principal Component Analysis was used to test the correlation between the variables collected. A multiple linear regression was then conducted.

4. Results

Principal Component Analysis

The starting point in many ordination processes is a principal component analysis, PCA. This involves the eigen analysis or decomposition of the co-variance matrix or the correlation matrix to form eigenvectors that explain the variation in the observations using as few dimensions as possible. Each eigenvector is a combination of the observed variables, each of which has a certain weighting on the vector. The greater the weighting, the more important that variable is to the eigenvector.

The process of ordination assumes that the variation in the observations can be explained by fewer combined variables than the totality of observed variables. The observed variables are not all needed to explain the variation seen. Some of the observed variables may be unnecessary to explain all the variation in the objects; some do not add any information of their own.

The eigenvectors are known as principal components, and each provides a unique component of the total variation in the sample.

The first principal component accounts for as much of the variation as possible. The second accounts for as much of the remaining variation as possible while being orthogonal to the first- none of the variation accounted for overlaps. This continues throughout all the components.

Appendix 4 shows the results of the PCA. The results of this table are further described below.

From the PCA it was determined that the earlier MATH 309 students completed their first attempt on the assignment, the better their scores were (-0.490; p-value 0.05). This was concluded from the strong correlation between the MATH 309 Total Score and the MATH 309 Average Time of First Completion, indicating the time before the due date when students started the online homework. The time represented was presented in terms of its reciprocal in order to emphasize the difference between a student starting their homework on the day it was due versus a student starting their homework four days before it was due.. The same method was used on the average login time, the time of completion of the first attempt, the time of completion of the last attempt, and the total number of time students accessed the help tutorial for the particular problem. Some of the strongest correlations were between the number of times students sought online help in a semester and the total number of attempts in a semester in both the MATH 308 and 309 classes (0.802; 0.724; p-value 0.05). Surprisingly, the 308 course grade was negatively correlated to the total number of times a student accessed help (-0.666; p-value 0.05); however, the 308 course grade was correlated to the total number of attempts (-0.454; p-value 0.05). Both 308 and 309 students' total score correlated to the total attempts (0.419; 0.678; p-value 0.05) made by the students. Our results seem to support the findings by Verbych (2005). Verbych states, "This conclusion is reasonable since the students who start earlier have more time to work the problems and have more possibilities to get live help . . . from their instructor before the due date, rather than merely procedurally following the online help." This data could also support a similar result from Verbych's work relating understanding to the number of attempts on the online homework. It appears that the students with the best conceptual understanding tended to attempt the online homework a sufficient number of times to learn the material, but not necessarily enough to memorize the procedures without understanding the concepts.

Questionnaire Results

We were only able to use 18 students in this study. The following table shows these students' reported scores for each of the sections of the questionnaires. Interpretations are in the sections that follow the table.

Table 3. Student's reported multiple intelligence and learning style scores. Multiple Intelligence Identification: 1-Linguistic; 2-Musical/Rhythmic, 3-Mathematical/Logical; 4-Naturalist; 5-Visual/Spatial; 6-Interpersonal; 7-Bodily/Kinesthetic; 8-Intrapersonal. Learning Styles Identification: Active, Sensing, Visual, and Sequential learners reported negative scores; Reflective, Intuitive, Verbal, and Global reported positive scores; the further reported scores are from zero signifies significant pulls to one learning style over another. * means no data submitted by student.

	Multiple Intelligence								Learning Styles			
Student Number	1	2	3	4	5	6	7	8	Active/ Reflective	Sensing/ Intuitive	Visual/ Verbal	Sequential/ Global
1	14	19	13	12	16	17	15	14	*	*	*	*
2	9	13	10	15	15	18	15	18	*	*	*	*
3	11	10	13	19	14	17	17	14	*	*	*	*
4	19	11	21	9	22	20	13	16	-1	3	-11	-3
5	19	18	16	23	24	21	24	21	-7	-1	-9	5
6	18	19	24	9	16	23	13	17	5	-5	-3	1
7	22	13	28	24	20	25	21	27	1	1	3	-5
8	20	19	20	18	21	18	22	19	*	*	*	*
9	25	26	19	23	22	27	23	24	*	*	*	*
10	14	13	13	11	18	22	24	23	*	*	*	*
11	17	13	20	19	22	19	22	15	*	*	*	*
12	18	16	24	25	24	22	28	24	*	*	*	*
13	15	15	16	11	22	23	25	23	1	-1	-7	-7
14	17	7	12	22	23	17	11	22	-3	1	-7	-3
15	17	19	19	16	18	19	17	19	1	-7	-7	-5
16	18	19	26	11	24	23	19	18	1	-5	-9	-1
17	16	23	10	13	21	22	18	17	-3	-1	-7	-5
18	22	18	14	18	18	25	16	27	-3	-7	-1	-3

Findings to MI

Only six of the multiple intelligences were shown to have any correlation to the other variables. The total MATH 308 online homework score was shown to have a positive correlation to visual/spatial and linguistic intelligences (0.444; 0.455; p-value 0.05). This would be an expected finding since the online homework would seem to be more amenable to students within these intelligences. However, it is not clear at this time why this finding was not seen in the total MATH 309 online homework score, which showed a positive correlation to the naturalist intelligence (0.405; p-value 0.05).

The total number of times MATH 308 students accessed the online help had a negative correlation to musical/rhythmic intelligences, while the total number of times MATH 309 students accessed the online help had positive correlations to visual/spatial, bodily/kinesthetic, and intrapersonal intelligences (0.435; 0.650; 0.490; p-value 0.05). At this time I cannot offer any insight as to the reasoning behind this.

Findings to ILS

The ILS was only taken by 10 students and this could be why we saw less correlation with this data. The final MATH 308 course grade appeared to have a correlation to sensing learners rather than intuitive learners (-0.405; p-value 0.05). Felder states that "sensors often like solving problems by well-established methods and dislike complications and surprises" (Felder and Soloman 1993). This statement could describe CSUMB learners because the online homework problems all have very specific steps that can be used to solve the problems. All of the average login times, average first attempt times and the last attempt time for MATH 309 correlated with the reflective learners (0.503; 0.504; 0.548; 0.418; p-value 0.05). These results would correlate with a reflective learner's frame of mind. Felder describes reflective learners as people who would like time to think about problems before actually doing them (Felder and Soloman 1993). By starting the online homework early, these learners would have time to think and even ask questions that would help them think about how to do the problem.

Multiple Regression

Regression analysis is a technique which develops a mathematical equation to analyze the relationship between two or more variables. "If we have simultaneous measurements for more than two variables, and one of the variables is assumed to be dependent upon the others, then we are dealing with a multiple regression situation" (Zar 1999). The correlation coefficient measure the linear relationship between two variables. If the relationship is nonlinear, any interpretation of the correlation will be misleading. For the interpretations of this section, we used a p-value of 0.25 to show significance because of the small sample size.

In the regression analysis of the variables MATH 308 total helps, total online homework score, average time of login, first attempt, and last attempt as well as the same information for MATH 309 against the dependent variable of the MATH 308 course grade we found a linear relationship (p-value 0.54; Table 4). Table 5 provides results of the multiple regression analysis. The MATH 308 total score, average login time, first attempt time, and last attempt time along with the MATH 309 total attempts and total helps were all predictive of the MATH 308 course grade. The R^2 value shows that 94.4% of the variation in the dependent variable is explained by the model.

Table 4. ANOVA results for multiple regression. Predictors are listed with the dependent variable MATH 308 course grade.

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.839	12	.487	5.669	.054[a]
	Residual	.343	4	.086		
	Total	6.182	16			

a. Predictors: (Constant), AvLAtt309, TotAt308, TotSc309, TotSc308, Av1Att309, TotAt309, TotHe308, TotHe309, AvLAtt308, Av1Att308, AvLo308, AvLo309

b. Dependent Variable: Grade308

Table 5. Multiple regression results for the dependent variable MATH 308 course grade. * means variable provides significant predictive ability.

	MATH 308 Course Grade		
Variable	β	t	p
Constant	-0.190	-0.111	0.917
MATH 308 Total Score	0.034	1.783	0.149*
MATH 308 Total Attempts	-0.041	-0.900	0.419
MATH 308 Total Helps	-0.004	-0.140	0.895
MATH 308 Average Login	22.646	2.001	0.116*
MATH 308 Average First Attempt	-20.912	-3.237	0.032*
MATH 308 Average Last Attempt	3.554	2.219	0.091*
MATH 309 Total Score	-0.002	-0.060	0.955
MATH 309 Total Attempts	0.143	1.952	0.123*
MATH 309 Total Helps	-0.064	-2.182	0.095*
MATH 309 Average Login	2.137	-0.447	0.678
MATH 309 Average First Attempt	0.854	0.375	0.727
MATH 309 Average Last Attempt	0.079	0.696	0.525
R^2		0.944	

The regression analysis of the multiple intelligence variables against the dependent variable of the MATH 308 course grade shows a linear relationship (p-value 0.110; Table 6). Table 7 shows the results of the multiple regression analysis. Only the linguistic intelligence shows an ability to be predictive of the MATH 308 course grade (p-value 0.105). This regression however, has a lower R^2 value of 71.2% accounting for less variation explained in the model.

Table 6. ANOVA results for multiple regression. Predictors are listed with the dependent variable MATH 308 course grade.

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.405	8	.551	2.478	.110[a]
	Residual	1.778	8	.222		
	Total	6.182	16			

a. Predictors: (Constant), MIintra, MImusic, MImath, MIspace, MInature, MIkinest, MIinter, MIlang

b. Dependent Variable: Grade308

Table 7. Multiple regression results for the dependent variable MATH 308 course grade. * means variable provides significant predictive ability.

	MATH 308 Course Grade		
Variable	β	t	p
Constant	1.932	1.570	0.155*
Verbal/Linguistic	0.130	1.826	0.105*
Musical/Rhythmic	0.017	0.428	0.680
Mathematical/Logical	0.025	0.771	0.463
Naturalist	0.013	0.395	0.703
Visual/Spatial	-0.001	-0.025	0.981
Interpersonal	0.009	0.098	0.925
Bodily/Kinesthetic	-0.019	-0.522	0.616
Intrapersonal	-0.069	-1.159	0.280
R^2		0.712	

Course Grade vs. Effort

We have not yet conducted interviews to determine conceptual understanding. However, we considered MATH 308 course grade versus total number of attempts in MATH 308 online homework, and there were similarities with Verbych's (2005) cluster analysis of conceptual understanding versus online attempts. The 18 subjects examined so far in this pilot study appear to be a group of students who try to learn the material conceptually, if we correlate learning conceptually with course grade. When these students are compared to all the MATH 308 students we can see a pattern similar to the Verbych's cluster analysis (graphing as online attempts versus conceptual understanding; Figure 6). We have some distinct patterns in our sample. Figure 7 shows students on the left who for the most part don't appear to try the online homework. The students on the right appear to try too hard, while students who had a total number of attempts in the MATH 308 semester of 13-26 (approximately 1 to 2 attempts per semester) and had a high course grade, learned conceptually.

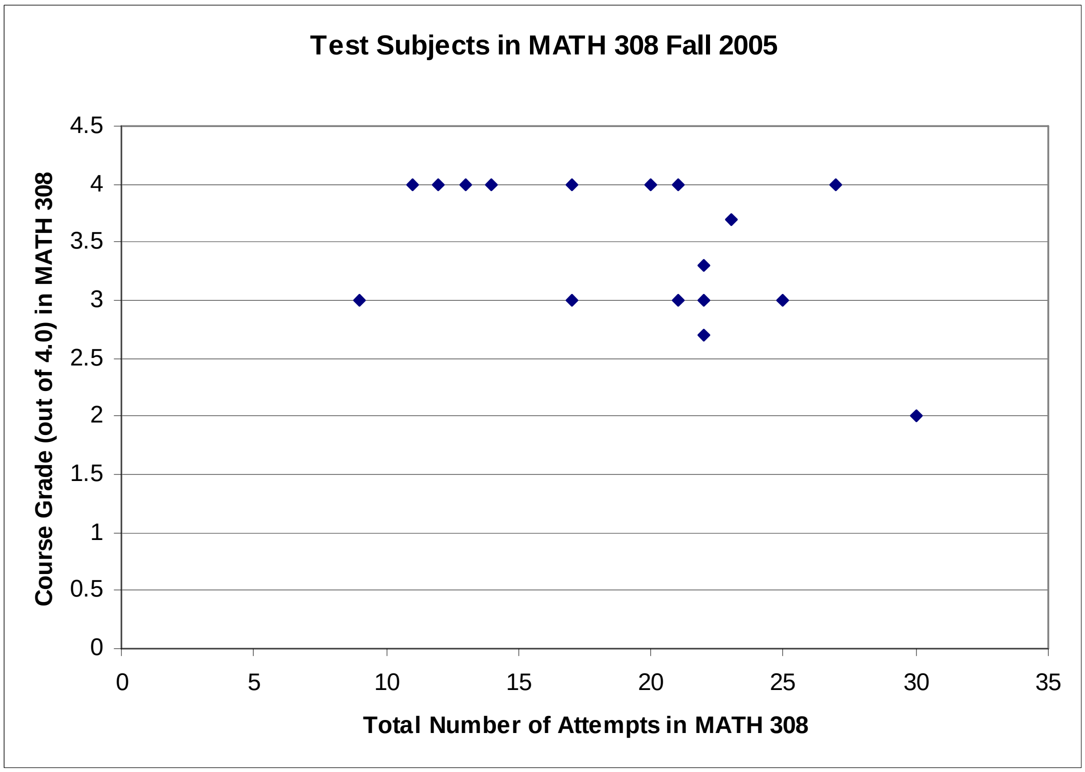


Figure 6. Scatter plot of course grade versus total number of attempts of pilot study test subjects.

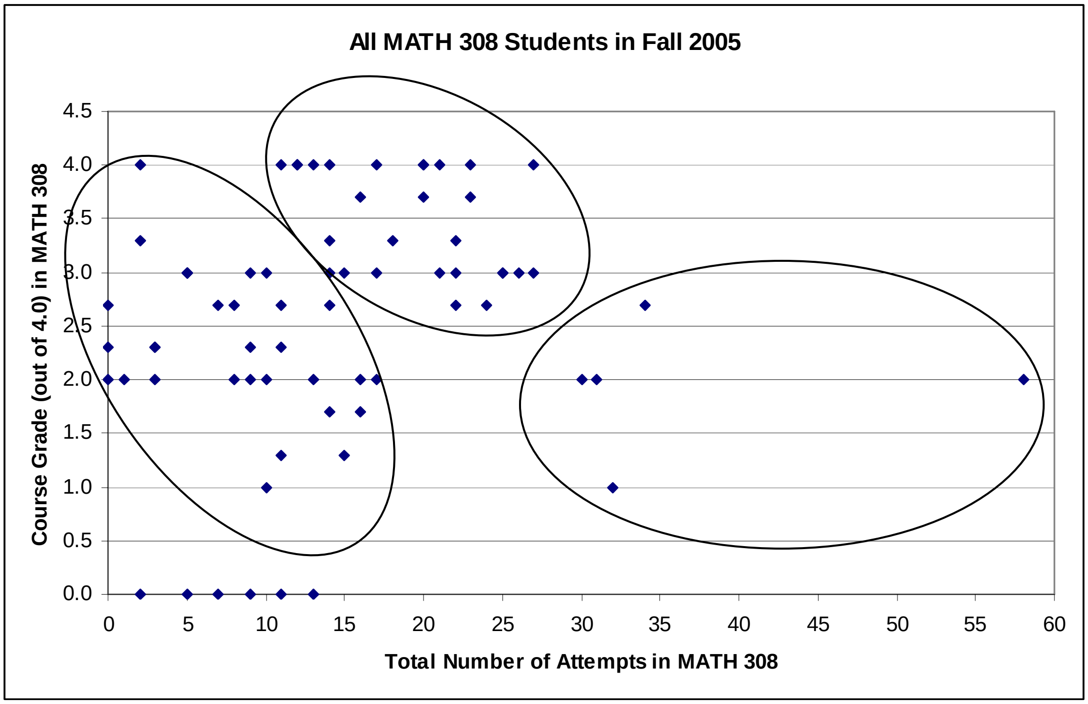


Figure 7. Scatter plot of course grade versus total number of attempts for all students enrolled in MATH 308 in Fall 2005.

6. Conclusions

Scott (2006a) states that "the purpose of the online homework systems is to provide an additional platform and assessment tool that facilitates computational competency in the course content". Online homework in CSUMB's MATH 308/309 courses is used in conjunction with journal assignments to assess the ability of future instructors in both teaching concepts and understanding the concepts they will teach. This pilot study shows a strong similarity between the CSUMB students and the students involved in Verbych's study at Kansas State University. Future studies should verify these similarities with additional online homework data. Because this is a new system, data can average out as the semesters' progress and one of the current issues in a couple homework assignments has been getting the assignment online in a timely manner.

More information needs to be gathered in relation to the online attempts and course grade (Figure 6, 7). Interviews will be needed to determine the level of conceptual understanding by students in the MATH 308 and 309 courses. Interviews should mimic what Verbych presented in her thesis, but would need to be geared towards pre-service teachers.

The strong similarity found in the PCA between the number of times students sought online help and the total number of attempts for both MATH 308 and MATH 309, should be furthered studied to see if the trend continues in future semesters and other mathematics courses that use online homework system. Based on the data further study should also examine the correlations between visual/spatial, musical/rhythmic, bodily/kinesthetic, intrapersonal, and linguistic intelligences as well as active and reflective learners, and sensing and intuitive learners as described in the results section. The unexpected correlation between MATH 308 online homework total score and the visual/spatial intelligence counterintuitive because the work in MATH 309 is more spatial and visual work than MATH 308. Further investigation is needed into the correlation between the total MATH 308 homework score and the visual/spatial intelligence because the MATH 309 course has more items described in this intelligence. However, the linguistic intelligence correlating with the MATH 308 scores is intuitive because the specialized syntax for computers relates to these students.

Initial multiple regression analysis showed the MATH 308 course grade has predictive variables that are able to create a linear relationship. With the multiple intelligences, linguistic intelligence will need to be examined further to not only determine why it is creating this linear relationship, but also if the trend becomes stronger with a larger sample size.

Issues around sex and race differences in intelligence continue to incite considerable debate and were not examined in this study. Future studies should also examine differences between these factors. Another future aspect of this study will be interviews that will be used to determine conceptual understanding of students.

Summary of Contributions

In this capstone, the initial analysis of online mathematics was presented. This analysis provides a focus for further analysis of the Mathematical Online Homework Project. This capstone also presents the original idea of using learning styles and multiple intelligences as variables that could affect mathematical online learning at CSUMB.

7. Acknowledgements

A big thank you to Dr. Michael Scott. I was fortunate to return from Australia and have someone take on the complicated task of being my capstone advisor when the only thing I knew I wanted to do was "something statistics related". Dr. Scott has been invaluable in helping me not only plan what I wanted to do, but throughout the entire process of making this capstone.

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8. Literature Cited

Anderson, T and F. Elloumi, editors. 2004. Theory and practice of online learning. Athabasca, Canada: Athabasca University. 454p.

Armstrong, T. 1994. Multiple intelligences in the classroom. Alexandria, VA: Association for the Supervision and Curriculum Development. p 185.

Brew, CR. 2002. Kolb's learning style instrument: sensitive to gender. Educational and Psychological Measurement. 62(2):373-390.

Brusilovsky, P. 2001. Adaptive hypermedia. User Modeling and User-adapted Interaction. 11(2/3):87-110.

Bush, GW. 2006. State of the Union: American competitiveness initiative. Available from: http://www.whitehouse.gov/news/releases/2006/01/20060131-5.html.

Clark, RE. 2001. A summary of disagreements with the "mere vehicles" argument. In R.E. Clark (Ed.), Learning from media: arguments, analysis, and evidence (pp. 125-136). Greenwich, CT: Information Age Publishing Inc.

CSUMB Catalog. 2006. Available from: CSUMB.EDU/catalog.

Dunn, R. 1984. Learning style: state of the science. Theory into Practice. 23(1):10-19.

Federico, P. 2000. Learning styles and student attitudes toward various aspects of network-based instruction. Computers in Human Behavior. 16:359-379.

Felder, RM and E.R. Henriques. 1995. Learning and teaching styles in foreign and second language education. Foreign Language Annals. 28(1):21-31.

Felder RM and B.A. Soloman. 1991. Index of Learning Styles. Available from: http://www.ncsu.edu/felder-public/ILSpage.html

Felder RM. and J. Spurlin. 2005. Applications, reliability and validity of the Index of Learning Styles. International Journal of Engineering Education. 21(1):103-112.

Gardner, H. 1983. Frames of mind: the theory of multiple intelligences. New York: Basic Books.

Gardner, H. 1993. Frames of mind: the theory of multiple intelligences. London: Fontana Press. p 439.

Gardner, H. 1995. Reflections on multiple intelligences: myths and messages. Phi Delta Kappan. pp. 200-209.

Gardner, H. 1998. A multiplicity of intelligences. Scientific American, Inc. pp. 18-23.

Gardner, H. 1999. Intelligence reframed: multiple intelligences for the 21st century. New York: Basic Books.

Gardner, H. 2003. Multiple intelligences after twenty years. American Educational Research Association; 2003 April 21; Chicago, IL. 14 p.

Gregoric, A. 1979. Learning/teaching styles: potent forces behind them. Educational Leadership. 36(4).

James W. & D. Gardner. 1995. Learning styles: implications for distance learning. New Directions for Adult and Continuing Education. 67.

Keri, G. 2002. Male and female college students' learning styles differ: an opportunity for instructional diversification. College Student Journal. 36(3):433-442.

KoIb, DA. 1984. Experiential learning: experience as the source of learning and development. Prentice Hall: Englewood Cliffs, N.J.

McGrath, H. and T. Noble. 2005. Eight ways at once. Sunnybank South, QLD, Australia: World of Books. 264 p.

[NCTM] National Council of Teachers of Mathematics. 1991. Professional Standards for Teaching Mathematics. Reston, VA: National Council of Teachers of Mathematics.

[NCTM] National Council of Teachers of Mathematics. 1989. Curriculum and Evaluation Standards for School Mathematics. Reston, VA: National Council of Teachers of Mathematics.

National Research Council. 2001. Adding it up: helping children learn mathematics. J. Kilpatrick, J. Swafford, and B. Findell (Eds.). Mathematics Learning Study Committee, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.

Perry, C. and I. Ball. 2004. Teacher subject specialisms and their relationships to learning styles, psychological types and multiple intelligences: implication for course development. Teacher Development. 8(1):9-28.

Riding R. & S. Rayner. 1998. Cognitive styles and learning strategies: understanding style differences in learning and behaviour. David Fulton Publishers

Scott, MB. 2006a. California State University Monterey Bay: CSU research, scholarship, and creative activity awards. Draft proposal. 7p.

Scott, MB. 2006b. Online homework use and advice – Spring 2006.

Simonson, M., S. Smaldino, M. Albright, S. Zvacek. 2002. Teaching and learning at a distance, 2nd Ed. Upper Saddle River, NJ: Prentice-Hall.

SPSS for Windows. 2001. Rel. 11.0.1. Chicago: SPSS Inc.

Verbych, E. 2005. Student work and success using online homework in a trigonometry class [Master's Thesis]. Manhattan (KS): Kansas State University. 51 p.

Vincent, A. & D. Ross. 2001. Personalized training: determine learning styles, personality types and multiple intelligence online. The Learning Organization. 8(1):36-43.

Zar, JH. 1999. Biostatistical analysis 4th edition. London: Prentice-Hall.

Appendix 1.

Committee for the Protection of Human Subjects, CSUMB
CONSENT TO PARTICIPATE IN RESEARCH

Title of Project: Learning Styles Affecting Student Learning in On-Line Based Education Systems

---

We would like you to participate in a research study conducted by Christina Schmunk, Mathematics Capstone Student, and Dr. Michael Scott, Ph.D., Assistant Professor for Mathematics and Statistics Department to be used for a Mathematics Capstone Project at California State University, Monterey Bay.

The purpose of this research is to determine how multiple intelligences affect student learning in on-line homework environments.

You were selected as a participant in this study because you enrolled in a MATH 308/309 – Elementary Math from an Advanced Viewpoint A/B or MATH 130 – Pre-Calculus class.

Students learn mathematics in various ways. For example, some students learn more easily through written examples, and others through pictures. Participants in the project will obtain a better understanding of their own learning styles, which will help them better learn mathematics.

If you decide to participate in this research, you will be asked to complete two multiple intelligence tests that consists of approximately 60 questions, the on-line homework assigned for the class, and class exams.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will only be disclosed with your written or witnessed verbal permission or as required by law. A random number will be assigned to you and will be used to maintain your results of the multiple intelligence test, on-line homework, and exams. Researchers for this study will be able to use this number to know who you are in case we have questions or need to conduct a verbal interview. Otherwise, no one outside the researchers of this study will be allowed access to the information we collect.

This research project may involve interviews. The interview will be audio- or videotaped. The researchers will have access to the recorded interviews and they will be used for educational purposes only. If you volunteer to participate in the interview portion of the study, then you will have the right to review the tapes.

Taking part in this project is entirely up to you. You can choose whether or not to be in the study. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you do not want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which warrant doing so.

If you want to know more about this research project or have questions or concerns, please email me at christina_schmunk@csumb.edu. You may also contact Dr. Michael Scott, Assistant Professor, Mathematics Department at (831) 582-4229 or via email at michael_b_scott@csumb.edu.

The project has been reviewed and accepted by California State University, Monterey Bay. You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study.

If you have questions about CSUMB's rules for research, please call the Committee for Human Subjects Chair, Chip Lenno, CSUMB Technology Support Services, 100 Campus Center, Building. 43, Seaside CA 93955, 831.582.4799.

You will get a copy of this consent form. Thank you for considering participation.

Sincerely,
Christina Schmunk, Student
Dr. Michael Scott, Assistant Professor

Consent Statement

I understand the procedures described. My questions have been answered to my satisfaction and I freely agree to participate in this study. I know what I will have to do and that I can stop at any time.

I have been given a copy of this Consent Form.

____ _______________________

Signature Date

Signature of Researcher

In my judgment, the participant is voluntarily and knowingly giving informed consent and possesses the legal capacity to give informed consent to participate in this research study.

____ _______________________

Signature of Researcher Date

Appendix 2. Multiple Intelligence Questionnaire

Answer the following as: Very True of Me, Mostly True of Me, Somewhat True of Me, Not True of Me

1. I am well coordinated and feel confident that I can make my body do what I want it to do
2. I write well and I can usually find the right words to say what I mean and communicate my ideas
3. I have a good 'ear' for music and can usually tell when a note is off-key or someone is singing or playing incorrectly
4. I like to spend time in nature and I see details in insects, plants and trees that others miss
5. I am good at analyzing how each person is different and their personalities, motivations and strengths
6. A job I would be good at is one with quite a lot of reading and writing to do
7. I can successfully read maps and use them to find my way around. I have a good sense of direction and rarely get lost
8. I find it relatively easy to do practical math in my head (e.g.calculating costs/change and amounts)
9. I am good at finding the logical flaws and inconsistencies in argumentsand ideas
10. Music is an important part of my leisure time. I listen to it a lot and go to musical concerts when I can
11. I am able to differentiate between many different insects, birds or animals because I observe a lot
12. People often come to me to talk about their problems and for personal advice
13. I know a lot about myself and I understand my own behavior and feelings pretty well most of the time
14. I am good at miming and playing charades
15. I often notice small visual details that other people don't see and I remember visual details well
16. After something has upset me I try to understand my reactions and find ways to calm down and deal with it
17. I am good at imagining how something will look before I make it (e.g. renovations, designs, models, clothing)
18. I can recognize and name many trees and plants
19. I am good at working out how I am both similar to and different from other people I know and meet
20. English and languages are (were) among my favorite subjects at school and I do (did) well in them
21. I am very sensitive to other people's feelings. I can usually 'read' how they are feeling and help where needed
22. Mathematics and Science are (were) among my favourite subjects at school and I do (did) well in them
23. A job I would be good at is one that involves using my body or hands
24. I am good at deciding on a goal, working out how to do it, then persisting until I achieve it
25. I could learn most new sporting, exercise or dance skills pretty easily if I chose to
26. I like and am good at word puzzles and word games

27. I take part in art, design or craft activities or lessons in my leisure time and I am quite good at them
28. When I was younger I had a very strong interest in nature and I collected specimens or raised animals or birds
29. I have a very strong interest in music and I have always been good at learning new songs and tunes
30. I am good at brainteasers, math puzzles and playing strategic games like chess
31. I am skilled at using grammatically correct sentences and I have an extensive general vocabulary
32. I am good at working out which elements, when combined, form different styles of music (e.g. country, classical, rock)
33. I am good at working with my hands to make things (e.g.carpentry, sewing, model building, origami)
34. I am a good speller and I take pride in spelling words correctly
35. Animals usually respond well to me because I have a natural affinity with them and care about them
36. I tend to take on the role of organizer when I am around others. I do it pretty efficiently and others respond well to me
37. I am a very keen reader in my leisure time and I read quickly and fluently
38. A job I would do well is one that involves either handling math/numbers or doing scientific analysis or research
39. I know how to play a musical instrument and I have shown some talent at it
40. I can successfully adjust my behavior so that I can get along well with a wide variety of people
41. I can quickly recognize familiar songs even when they are differently orchestrated or without words
42. I am good at logical thinking and argument of the kind used in debates
43. A job I would be good at is one that involves working with nature in some way, e.g. a forest ranger, vet, marine biologist
44. I have spent a lot of my leisure time doing sports or other forms of physical activity and I am reasonably good at it
45. I am good at acting in plays and I can effectively communicate a character to an audience
46. I can accurately identify my strengths and weaknesses and predict how good I will be at something
47. I have a good sense of design and can work out which things look better and why, and which things go well together
48. I am good at showing and teaching others how to do things and I would do well in a job where I had to do a lot of that
49. Art or graphics or technical drawing is (was) a favorite subject at school and I do (did) well in it
50. I am motivated to find out about myself and I do quizzes or read books to improve my self-knowledge
51. I can 'see' a situation more readily if I can measure, count, categorize or analyze the material
52. I can usually work with small parts to fix things because I have good control over my hands and fingers
53. I am skilled at growing things - they mostly thrive

54. I can see clear visual images in my head of the things I am thinking about or remembering
55. I sing reasonably well and I can 'carry a tune' and sing harmoniously with others
56. I like to write down my experiences and my reactions to them so that I can reflect and learn from them

Appendix 3. Learning Styles Questionnaire

1. I understand something better after I
a. try it out.
b. think it through.

----

2. I would rather be considered
a. realistic.
b. innovative.

----

3. When I think about what I did yesterday, I am most likely to get
a. a picture.
b. words.

----

4. I tend to
a. understand details of a subject but may be fuzzy about its overall structure.
b. understand the overall structure but may be fuzzy about details.

----

5. When I am learning something new, it helps me to
a. talk about it.
b. think about it.

----

6. If I were a teacher, I would rather teach a course
a. that deals with facts and real life situations.
b. that deals with ideas and theories.

----

7. I prefer to get new information in
a. pictures, diagrams, graphs, or maps.
b. written directions or verbal information.

----

8. Once I understand
a. all the parts, I understand the whole thing.
b. the whole thing, I see how the parts fit.

----

9. In a study group working on difficult material, I am more likely to
a. jump in and contribute ideas.
b. sit back and listen.

----

10. I find it easier
a. to learn facts.
b. to learn concepts.

----

11. In a book with lots of pictures and charts, I am likely to
a. look over the pictures and charts carefully.
b. focus on the written text.

----

12. When I solve math problems
a. I usually work my way to the solutions one step at a time.
b. I often just see the solutions but then have to struggle to figure out the steps to get to them.

---

13. In classes I have taken
a. I have usually gotten to know many of the students.
b. I have rarely gotten to know many of the students.

---

14. In reading nonfiction, I prefer
a. something that teaches me new facts or tells me how to do something.
b. something that gives me new ideas to think about.

---

15. I like teachers
a. who put a lot of diagrams on the board.
b. who spend a lot of time explaining.

---

16. When I am analyzing a story or a novel
a. I think of the incidents and try to put them together to figure out the themes.
b. I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

---

17. When I start a homework problem, I am more likely to
a. start working on the solution immediately.
b. try to fully understand the problem first.

---

18. I prefer the idea of
a. certainty.
b. theory.

---

19. I remember best
a. what I see.
b. what I hear.

---

20. It is more important to me that an instructor
a. lay out the material in clear sequential steps.
b. give me an overall picture and relate the material to other subjects.

---

21. I prefer to study
a. in a study group.
b. alone.

---

22. I am more likely to be considered
a. careful about the details of my work.
b. creative about how to do my work.

---

23. When I get directions to a new place, I prefer

a. a map.
b. written instructions.
----
24. I learn
a. at a fairly regular pace. If I study hard, I'll get it.
b. in fits and starts. I'll be totally confused and then suddenly it all clicks.
----
25. I would rather first
a. try things out.
b. think about how I'm going to do it.
----
26. When I am reading for enjoyment, I like writers to
a. clearly say what they mean.
b. say things in creative, interesting ways.
----
27. When I see a diagram or sketch in class, I am most likely to remember
a. the picture.
b. what the instructor said about it.
----
28. When considering a body of information, I am more likely to
a. focus on details and miss the big picture.
b. try to understand the big picture before getting into the details.
----
29. I more easily remember
a. something I have done.
b. something I have thought a lot about.
----
30. When I have to perform a task, I prefer to
a. master one way of doing it.
b. come up with new ways of doing it.
----
31. When someone is showing me data, I prefer
a. charts or graphs.
b. text summarizing the results.
----
32. When writing a paper, I am more likely to
a. work on (think about or write) the beginning of the paper and progress forward.
b. work on (think about or write) different parts of the paper and then order them.
----
33. When I have to work on a group project, I first want to
a. have group brainstorming where everyone contributes ideas.
b. brainstorm individually and then come together as a group to compare ideas.
----
34. I consider it higher praise to call someone
a. sensible.
b. imaginative.

---

35. When I meet people at a party, I am more likely to remember
a. what they looked like.
b. what they said about themselves.

---

36. When I am learning a new subject, I prefer to
a. stay focused on that subject, learning as much about it as I can.
b. try to make connections between that subject and related subjects.

---

37. I am more likely to be considered
a. outgoing.
b. reserved.

---

38. I prefer courses that emphasize
a. concrete material (facts, data).
b. abstract material (concepts, theories).

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39. For entertainment, I would rather
a. watch television.
b. read a book.

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40. Some teachers start their lectures with an outline of what they will cover. Such outlines are
a. somewhat helpful to me.
b. very helpful to me.

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41. The idea of doing homework in groups, with one grade for the entire group,
a. appeals to me.
b. does not appeal to me.

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42. When I am doing long calculations
a. I tend to repeat all my steps and check my work carefully.
b. I find checking my work tiresome and have to force myself to do it.

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43. I tend to picture places I have been
a. easily and fairly accurately.
b. with difficulty and without much detail.

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44. When solving problems in a group, I would be more likely to
a. think of the steps in the solution process.
b. think of possible consequences or applications of the solution in a wide range of areas.

Appendix 4. Correlations between testing variables.

	Mean	SD	308 Grade	TotSc308	TotAt308	TotHe308	AvLo308	Av1Att308	AvLAtt308	TotSc309	TotAt309	TotHe309	AvLo309	Av1Att309	AvLAtt309
308 Grade	3.4530	0.6216	1												
TotSc308	102.5350	9.3060		1											
TotAt308	19.1800	5.8870	-0.454	0.419	1										
TotHe308	16.7100	14.0750	-0.666		0.802	1									
AvLo308	0.0648	0.1367					1								
Av1Att308	0.0922	0.1603					0.993	1							
AvLAtt308	0.1343	0.1971					0.873	0.902	1						
TotSc309	72.0120	17.4207					-0.657	-0.669	-0.802	1					
TotAt309	13.9400	4.6300		0.407	0.530		-0.582	-0.548	-0.515	0.678	1				
TotHe309	13.9700	11.4920			0.481	0.608					0.724	1			
AvLo309	0.2392	0.7574					0.972	0.969	0.808	-0.508	-0.494		1		
Av1Att309	0.4526	1.5056					0.967	0.961	0.792	-0.490	-0.497		0.999	1	
AvLAtt309	1.1306	3.0021					0.426	0.418				0.554	0.437	0.460	1
MIlang	16.8200	3.4680	0.686	0.455											
MImusic	15.5900	4.1690				-0.407									
MImath	17.5900	5.6690													
MInature	16.1800	5.3300								0.405					-0.408
MIspace	19.8800	3.3140		0.444							0.435				
MIinter	20.6500	2.7370													
MIkinest	18.8200	4.8380									0.650	0.533			
MIintra	19.6500	4.1520									0.490				
actref	-0.4700	2.5280					0.503	0.504					0.548	0.563	0.418
senint	-1.2900	2.8890	-0.405												
visver	-3.4100	4.3310													
seqglo	-1.5300	2.9390													

	MIlang	MImusic	MImath	MInature	MIspace	MIinter	MIkinest	MIintra	actref	senint	visver	seqglo
MIlang	1											
MImusic		1										
MImath	0.613		1									
MInature				1								
MIspace	0.531				1							
MIinter	0.559		0.449			1						
MIkinest					0.435		1					
MIintra	0.507			0.438		0.654	0.413	1				
actref			0.474	-0.430					1			
senint		-0.566								1		
visver					-0.500						1	
seqglo												1