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Does the use of differentiated performance tasks following Gardner's multiple intelligences theory improve my high school science students' opportunity to demonstrate their achievement?

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Abstract

The purpose of this study was to determine whether the implementation of differentiated performance tasks, by using Gardner's multiple intelligences (MI) theory, would improve my high school science students' opportunity to demonstrate their achievement. Six students served as primary subjects and were interviewed, and the entire class of twenty-two students provided documents for analysis and survey data. Evidence indicated an improvement in the validity of inferences of student academic achievement as a result of incorporating MI theory by allowing students to draw upon their respective, unique competencies.

Introduction

> We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness. (Thomas Jefferson, 1776)

Although our founding fathers declared that all people should have equal rights under the law, we are, in fact, unequal in terms of our individual intelligences, according to Harvard psychologist Howard Gardner who introduced the concept of multiple intelligences (MI) theory in 1983. Gardner proposes that each person is born with a unique profile of intelligences, varying along verbal-linguistic, logical-mathematical, bodily-kinesthetic, visual-spatial, musical, interpersonal, and intrapersonal dimensions. A naturalistic intelligence has since been described, and there has been subsequent discussion of adding an existential or spiritual intelligence as well (Gardner, 1999), suggesting that the list of identified intelligences may continue to expand.

Gardner's contention is that every person has a specific and distinctive manner by which he or she learns that corresponds to his or her combination of intelligences. For instance, a musician may relate to the world acoustically, whereas a mathematician may rely on algorithms and numerical patterns. We each have a unique intelligence profile, and no two people are exactly alike.

The implications for education of this theory are profound. MI theory can be applied to expand teaching and assessment strategies that reach more students, especially those who do not fit current models of education or who hail from impoverished and struggling backgrounds, including many who attend the school where I teach. By drawing upon these students' strengths, educators may be able to narrow the achievement gap. It is my impression that many schools have infused MI approaches to instruction and assessment in classrooms, hoping to reach students who have failed to benefit fully from traditional means.

With reauthorization of the Bush administration's 2001 No Child Left Behind Act (NCLB) looming, there is increasing pressure for educators to improve student achievement. Gardner's multiple intelligences theory may be an important arrow in the teacher's quiver. Traditional classrooms predominantly target only one or two of Gardner's intelligences: logical-mathematical and verbal-linguistic. Assignments limited to these two foci are typically rather straightforward to create and grade. However, many students do not learn in these ways, and such assignments may fail to measure accurately what they know. I conducted research providing differentiated assignment options in the hope of gaining better indicators of individual achievement for my students.

> *Research question*: Does the use of differentiated performance tasks following Gardner's multiple intelligences theory improve my high school science students' opportunity to demonstrate their achievement?

Research Site and Context

Fort Vancouver High School in Vancouver, Washington, where this research was conducted, enrolls Vancouver School District's lowest socioeconomic demographic, compared to the other three high schools, and the broadest ethnic and cultural diversity (Office of Superintendent of Public Instruction, 2008). Over 30 different languages are spoken by students, and the school's population is highly transient. Although there is wonderful variety in the student population, these factors are sometimes obstacles to students' academic success. I hoped that Gardner's MI theory might inform assessments such that my students' diversity could be honored and their achievements better recognized and credited.

Assessment Approach

Over the course of spring semester, 2009, students in my Pre-Advanced Placement (Pre-AP) Biology class, a single section course, were provided numerous ways to demonstrate their academic achievement. For research purposes, each assignment became a unit of analysis. Using a flowchart, I designated which assignments fell under the classification of either traditional or non-traditional categories. Traditional performance tasks targeted the logical-mathematical and visual-spatial domains and included quizzes, tests, and worksheets. Non-traditional assignments incorporated all other intelligences and included PowerPoint presentations, billboard formats, creative writing story options, and building projects. This system of cataloguing

individual assignments allowed me to compare and contrast performance (grades) between traditional and non-traditional methods.

Additionally, there were two open-choice unit projects with long lists of possibilities indexed to a broader spectrum of Gardner's defined intelligences. These gave students opportunities to determine which type of assignment each wished to complete and, thus, to signal which intelligence they preferred to utilize. Students were directed to choose one traditional and one non-traditional option so that results could be compared to their intelligence profiles as defined by both self-report in interviews and on a survey.

All students were provided with a questionnaire featuring ten statements describing each of the seven main intelligences identified by Gardner. All students check-marked statements that self-described their intelligences. A bar graph was created to depict each student's personal multiple intelligence profile. Students had opportunities to demonstrate their learning of scientific concepts in accordance with Gardner's multiple intelligences theory in the form of both traditional (i.e., verbal-linguistic and logical-mathematical intelligences) and non-traditional (i.e., the other MI modalities) performance tasks during this study.

Literature Review

In 1983, Howard Gardner proposed the theory of multiple intelligences (MI) as a new paradigm to describe how individuals learn and apply skills and information. According to him, each person is innately gifted with a unique cognitive learning style. He categorized these multiple intelligences into seven different groupings: verbal-linguistic (spoken and written language), mathematical-logical (recognition of patterns, numbers, and factual knowledge), bodily-kinesthetic (movement), musical (rhythm, tone), visual-spatial (three-dimensional space and graphics), interpersonal (between people), and intrapersonal (self-reflection). Recently, he added an eighth, the naturalistic (outdoor awareness and interaction with life) intelligence. These intelligences are manifested by specific skill sets, but they are more than that. They are also ways of seeing, understanding, and interacting with the world, and are modes of expression. The relative strength of each of these intelligences constitutes a person's intelligence profile. Gardner's theory holds that each individual constructs information and knowledge based upon his or her mixture of intelligences, some stronger than others.

Conflicting Findings about Academic Benefits

Gardner introduced his theory in his book, *Frames of Mind* (1983), dedicating entire chapters to the description of each of the seven intelligences, their applications, and how to best utilize them. Since Gardner's publication over twenty years ago, MI theory has won the favor of many, although not all, educators. For example, a high school teacher who used and studied MI approaches with respect to instruction and assessment in an action research project offered this rationale:

> Ultimately, I am looking at multiple intelligences as a way of enhancing my science teaching. I want to be able to reach more students than I am presently reaching. In one of my classes, I have ESL students, and I feel that multiple intelligences activities will aid their learning. They're not always going to be using verbal-linguistic activities. . . That does not work. We need to look at other modes of learning. (Goodnough, 2001, p. 183)

His findings reflected that MI promoted greater interest in his students when learning scientific concepts and that they were more motivated to complete assignments.

Reporting another action research project conducted by a high school science teacher, Waters, Smeaton, and Burns (2004) reported similar student approval ratings of MI-based instruction and differentiated assessments. Sinclair and Coates (1999) found that 27% of their sixth-grade subjects improved their performances by an entire letter grade or more when MI theory in assessment was adopted in their science classes. Research in Turkey showed that fourth-grade students taught and assessed using MI techniques scored higher and retained scientific knowledge better than their control counterparts (Ozdemir, Guneysu, & Tekkaya, 2006). Teacher resource author, Brian Haggerty (1995), summarized:

> MI theory offers a richly diversified way of understanding and categorizing human cognitive abilities, and combinations of abilities, heightening our awareness of what makes learning possible for individual students. (p. 49)

Other researchers have confirmed the benefits reported by teachers. Kagan and Kagan (1998) agree that MI theory "is revitalizing the search for more authentic, student-centered approaches to curriculum, instruction, and assessment" (p. 23 as cited in Ozdemir, et al., p. 74). Even in higher education, implementation of MI theory is being explored. What originally started as a pilot study in the psychology department of Glendale Community College became accepted practice when it was determined that an MI approach bolstered student interest, success, and learning (Diaz-Lefebvre, 2004).

Nevertheless, critics of MI question whether or not Gardner's theory is just another educational fad. For example, Smith, Odhiambo, and El Khateeb (2000) found that an implementation of MI theory had no bearing on student academic achievement. Rather, they concluded that successful students shared similar behavioral skills missing from their less successful peers. Their statistical analysis of 60 high school students across several different academic subjects indicated that it was not MI that explained the success of some but, rather, the actions demonstrated by these highly successful students. Even some supporters of MI theory have noticed an apparent lack of significant scholastic improvement in student performance. For example, Goodnough's (2001) case study of a high school science teacher's action research project revealed no marked difference in the grades of students exposed to MI strategies and those of their non-MI control group. Not only did the experimental group fail to demonstrate considerable improvement on tests, but also they retained some scientific misconceptions.

Affective Benefits

Outside the scientific disciplines, MI theory has sparked success in the affective domain. In 1997, Dreher presented her results of MI theory application in an English classroom where standardized tests failed to measure success accurately. Such tests focus on the logical-mathematical and verbal-linguistic intelligences but utterly failed to address her students' other intelligences. Interestingly enough, her most scholastically adept students scored only moderately (average) or lower regarding these two types of intelligences and tended to favor other intelligences described by MI theory. Her findings call into question the validity of standardized tests as measures of intelligence or achievement.

Some teachers have infused MI approaches into their instructional and assessment practices as a result of disillusionment with existing instructional paradigms. Still, most science classrooms are dominated by lecture formats that favor only the verbal-linguistic and logical-mathematical intelligences, leaving many learners out of the educational experience (Thompson & MacDougall, 2002). Sinclair and Coates (1999), who used MI to give science a friendlier appeal to sixth-grade students, showed that students who had viewed science in a negative light reported a 52% positive approval rating thereafter. A post-secondary student at Glendale Community College similarly said:

> I think the type of student that would benefit would be the one that usually doesn't want to participate, the one that is just sick of regular school, it's never ending, it's always paperwork and book work. They don't try, and so they do badly on tests and stuff like that. But this gives them an opportunity to do something completely on their own. . . I think the kids in the back of the classroom that would usually never participate are given an opportunity to, "Okay, if you don't enjoy learning this way, you have your own choice." . . It's just that they get into a slump with the old style of teaching. (Diaz-Lefebvre, 2004, p. 54)

Students are not the only proponents of MI theory in the classroom. A biology instructor at the same college articulated the way in which affective benefits led to cognitive gains as well:

> Students need to take charge of their own learning. They need to participate in active learning, and they need to be exposed to learning in different ways. By doing [Multiple Intelligences/Learning for Understanding] learning options, we have helped in this process. I make students do research on the topic beyond the text or my notes, and then the students have to convince me that they understand the material. . . My students do not learn the way I learned and do not see things the way I do. By having their peers do learning options, some of the students may see the information in a way that makes more sense to them. (Diaz-Lefebvre, 2004, p. 55)

In another study, through cooperative learning (the domain of interpersonal intelligence), students became empowered and interactive participants in their own

education. Tinnzmann, Jones, Fennimore, Bakker, Fine, and Pierce (1990) found, "It is primarily through dialogue and examining different perspectives that students become knowledgeable, strategic, self-determined, and empathetic" (as cited in Smith, et al., 2000, p. 17).

One important reason for adopting an MI approach is to allow students to demonstrate authentically what they actually *do* know. Too many times, tests and quizzes measure only rote memory without targeting higher level cognitive skills, as one student said of traditional paper-and-pencil testing: "All I have to do is know the answer and not even understand it" (Waters, et al., 2004, p. 98).

Classroom Strategies and Applications

Incorporating MI theory into classroom instruction and assessment requires considerable time and creativity on the part of the teacher. Fortunately, educators are notoriously good at borrowing ideas, modifying them for their own uses, and sharing results with colleagues. Thompson and MacDougall (2002) offered numerous suggestions and practical applications as how to infuse MI theory into science classrooms, recommending a wide array of differentiated learning opportunities. Goodnough (2001) reported that a high school science educator had infused his teaching with MI techniques in order to establish a more student-centered classroom while individualizing assessment. Students in fourth grade accessed various learning centers in the study conducted by Ozdemir et al. (2006), intended to stimulate the different intelligences identified by Gardner. In one sixth-grade classroom, researchers offered students a variety of learning options beyond the traditional norm, each type designed to target a specific intelligence (Sinclair & Coates, 1999). Rubric-based assessment with differentiated learning outcomes formed the basis of another teacher's MI-based classroom (Waters, et al., 2004). Diaz-Lefebvre (2004) cited similar assessment strategies at the community college level where students were given learning options targeting their individual cognitive strengths.

My review of the literature revealed educational efforts to engage students by presenting them with varied opportunities to demonstrate their learning achievement. Most teachers want to stimulate their students' interests with educational opportunities and want students to be successful in school. Oftentimes, this forces teachers to re-evaluate their methods and strategies and to consider a paradigm shift. Gardner's multiple intelligences theory offers a new way to view instruction, assessment, and learning by encouraging teachers to see students as individuals, each with a specific intelligence profile featuring different cognitive strengths and weaknesses.

Methods

Research Approach

Although a time-series design was initially planned, this type of design's rigid demands regarding timing and scheduling proved incompatible with the structure of the

course I taught, as it conflicted with pedagogical sequencing and naturalistic conditions. Instead, my action research project took a mixed-methods approach.

Participants

Initially, a range sample of primary subjects was planned: two high-performing students (A to B+ range), two middle performers (B to C- range), and two struggling students (D+ to F range). Accordingly, a range sample of seven students was selected to represent not only different achievement levels but, more importantly, different intelligence profiles. Primary subjects included traditional students, non-traditional students, and students who demonstrated attributes of both categories of intelligences. Additionally, at least one student of each gender was selected in the three achievement groups. The low-achieving students were treated as a critical sample. Eighteen remaining students in the class served as secondary subjects.

A multiple intelligences questionnaire was given to each student at the start of data collection, a modified version of a survey administered by Sinclair and Coates (1999), adding questions available from an online site (McKenzie, 1999). From a list of descriptors, students self-identified their ideal modes of learning (see Appendix A). The results allowed me to classify the intelligence profiles of my students who were divided into two categories: traditional and non-traditional intelligences. Traditional students were those who favored more mainstream intelligences: both the logical-mathematical and visual-spatial domains. Non-traditional students preferred the other intelligences.

However, upon closer analysis of student self-report data from their questionnaires, a different grouping strategy was needed. In a revised sampling strategy, students were placed into two groups based on their grades which resulted in a better demographic balance. In the end, one male and one female traditional learner, one male and one female non-traditional learner were selected for each achievement group, as well as one student whose profile suggested flexible elements of both intelligence categories. Because one primary subject had potential attendance issues, an extra student was included in the lower performing cohort as a safeguard against attrition or uninterpretable data.

Data Collection

Data collection lasted six weeks, during which time one unit of several textbook chapters covered the origins of life, geologic time, and evolutionary theory. The mixed-methods approach involved quantitative data from student surveys with Likert-style items and assignment grades or scores, and qualitative data from open-ended questions on student surveys, interviews of primary subjects, and analysis of documents and artifacts.

Documents

Student artifacts and documents included work students produced during the six weeks of the study. These artifacts included billboards, PowerPoint presentations, quizzes, worksheets, essays, models, and artistic renderings. I classified each assignment as traditional or non-traditional based on the type of intelligence employed

by the student to fulfill the performance objective. These data were collected for the purpose of determining the effectiveness of implementing multiple intelligences theory in my classroom assessment practice.

Survey

An anonymous student survey collected information about the effectiveness of MI-based approaches. The questionnaire was field-tested with a former student prior to use. This instrument included both closed-ended (Likert-style) and open-ended items totaling around twenty questions. The purpose of the questionnaire was to obtain student perspectives regarding the implementation of MI theory in the classroom, although some questions delved into classroom management, topical issues, and the like, and thus were not pertinent to the focus of this study. Twenty-two student questionnaires were distributed during class time, and all of them were completed and returned.

Interview

Seven primary subjects were interviewed after school over a period of two weeks in June. The interview protocol was first field-tested with a student from a different class. Each subject was given time to read the prepared questions before the interview began in order to reduce anxiety. Each interview lasted approximately half an hour and was audio-taped for accuracy. Five main questions were developed and asked in a semi-structured manner to maximize flexibility in probing for depth. All recordings were transcribed within a day or two of the interview prior and validated by each interviewed student.

Data Analysis

The constant comparative method was followed for data collection and analysis (Glaser & Strauss, 1967). Themes were identified based on comparisons and contrasts that emerged from survey, interview, and academic performance data.

Student survey responses about the effectiveness of the MI-based assignment approaches were statistically analyzed and graphed. Open-ended statements embedded in the student surveys provided less structured but more individualized student information about the impact of MI techniques.

Interviews offered more depth regarding student perspectives about the efficacy of the strategies employed. Each interview was audio-recorded, transcribed and validated, then printed as components of individual student profiles. I underlined statements from each interview that elucidated specific key points, then triangulated with survey information and grades.

As the first step in data analysis, a subject-by-subject analysis of the primary subjects' student profiles included scrutiny of their multiple intelligences questionnaires in order to determine the strengths and weakness of each individual in those areas. To examine each student's multiple intelligences characteristics with his or her achievement

indicators, each primary subject's grades were cross-referenced with his or her self-report on the MI questionnaire and in interview. A basic description of each primary subject was written and added to his or her profile, including behavioral anecdotes. Absences and missing assignments were recorded, as well as patterns from individual interview data. Finally, at the end of each profile, a preliminary interpretation was generated as well as a basic overview of each student. For easy reference, all student profiles contained photocopied examples of all assignments generated by that student.

Performance data were also included in each student profile. Over the final four weeks of the school year, student grades were collected and compared. As the next step in data analysis, all assignments were sorted according to type: video sheets, scavenger hunts, quizzes, group presentation, worksheets, lab write-up, projects, and final exam. Each type was then categorized as traditional (targeting logical-mathematical and verbal-linguistic intelligences) or non-traditional (targeting all other MI intelligences) based on the intelligences required to complete each assignment. Tabulated averages of each of the two types of assignments helped determine the overall achievement for the student in a given intelligence domain. This became critical in analyzing student academic performance in class and in cross-referencing with interview and student self-reports on the MI questionnaire. Finally, pre- and post-unit grades were compared to determine how student academic rank shifted during the course of this study. Overall performances on assignments were listed from ascending to descending order (highest to lowest grades) in each intelligence category.

Limitations

Results from this study should not be over-generalized, as the students in the relatively small sample size of one class and may be distinct from students in other classes at other schools. Additionally, poor attendance hindered gathering sufficient data from each student participant. The profiles of the three primary subjects proved difficult to analyze due to limited data. One student failed to turn in three assignments, one of which was a non-traditional project to construct a geologic timeline. Another student missed ten assignments over the course of the unit, including both the non-traditional and the traditional unit projects. The sporadic attendance of a third also limited data collection, although she worked hard to make up all of her assignments. Some assignments could not be replicated because they were in-class group work or lab experiences.

Also, environmental factors beyond the scope of the classroom may have confounded somewhat the demonstration of significant impact from MI approaches. These factors included a lack of appropriate materials for students to demonstrate fully their learning due to poverty, all manner of family issues, and unexpected changes to the school schedule during the research time frame.

Scheduling issues may have interfered with the accuracy of some grades. For instance, many students received poor scores on the lab write-up in spite of a two-week deadline; most were incomplete. This assignment fell during the last full week of instruction prior to final exams, a time when many students may have felt overloaded

and stressed. In order to counteract this limitation, I allowed students to resubmit their lab reports (the only re-do allowed during this unit); however, few students took advantage of this opportunity.

Ethical Considerations

In order to respect student confidentiality, pseudonyms are used in place of all students' names in this report. Informed parental consent and student assent were obtained prior to the study.

Data Presentation and Analysis

Data gathered through documents analysis, survey, and interview were analyzed to answer the research question: *Does the use of differentiated performance tasks following Gardner's multiple intelligences theory improve my high school science students' opportunity to demonstrate their achievement?* One dominant theme emerged: the impact of MI assessments on the validity of classroom assessments.

Validity is the critical issue with respect to assessment. Myriad confounding factors and rival constructs threaten any assessment strategy and can undermine a teacher's ability to make informed inferences about student achievement. I sought to address this issue by broadening and deepening the types of assessments I used so that students with different intelligences could better demonstrate their respective progress.

Some students proved to be more aware of their MI strengths than others. The ability to determine insightfully ones' own capabilities is, according to Gardner's theory, a product of the individual's sense of self – the intrapersonal intelligence. When I cross-referenced students' self-reports on the MI questionnaire with their academic performance and interview data, this became clear, as the following summaries of three primary subjects' profiles attest.

Students' Self-Awareness

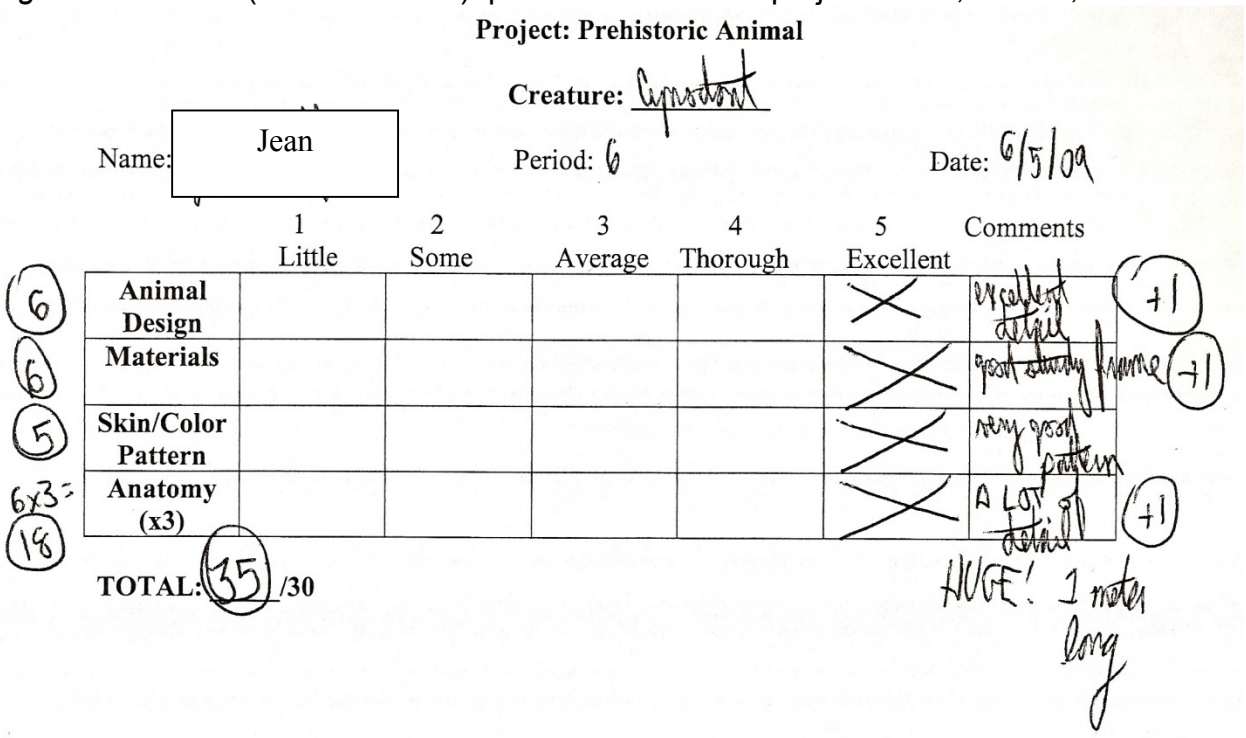
Jean. Although she self-reported both through interview and survey her preference for traditional learning strategies (primarily the logical-mathematical domain), Jean's classroom performance showed evidence of a more plastic, adaptable range of styles. She demonstrated strong evidence of an equally traditional and non-traditional modality, scoring well on assessments that required a wide variety of MI intelligences. The discrepancy between her self-reported and demonstrated intelligences confirmed her low intrapersonal score (3 out of 10). Perhaps Jean underestimated her other skills, was largely unaware of them, or preferred not to employ these talents, relying on what she perceived as her strengths instead.

For example, Jean exhibited remarkable creativity and artistic skill in completing a prehistoric creature project (see Figures 1-2) which required both the kinesthetic and visual-spatial intelligences. Jean self-reported in these two domains toward the bottom of the scale (3 and 4 out of 10, respectively). Nevertheless, her project was of high quality, unexpected size (three to four feet long), meticulously constructed, and met all

criteria as outlined on the project rubric. In fact, typical for her, Jean surpassed the expectations and earned extra credit on her project. She had chosen an option which required skills associated with non-traditional intelligences because "it seemed like it would be fun and the final product would be interesting" (survey response, June 15, 2009).

Jean's PowerPoint presentation was likewise outstanding (see Figure 3). A group effort, this assignment allowed Jean to reveal unexpected social and oratory skills. Jean displayed very good public speaking skills, talking clearly and with great articulation. She explained scientific concepts with observed ease, utmost clarity, and no apparent anxiety. In spite of her exceptionally low self-report interpersonal score of 1 out of 10), she worked extremely well with her partner, directing him to appropriate sources during the research phase of the project and assisting in the creation of the slideshow in a leadership capacity. Moreover, during the actual group presentation, Jean did not dominate her partner or the discussion, although she was quick to clarify key points about the Carboniferous Period when necessary. She performed all of these tasks with excellent competence, although she had self-reported a mediocre verbal-linguistic intelligence rating (5 out of 10). Finally, although she ranked herself below average with respect to the visual-spatial intelligence (4 out of 10), Jean's slideshow commendably displayed accurate and pertinent graphics (both text and pictures), a good layout format, and an appropriate number of slides. Although this could have been the result of her partner's input, I observed Jean's direct involvement in the creation of the PowerPoint. This again confirmed the under-rated nature of her self-report data.

Figure 1. Jean's (non-traditional) prehistoric creature project rubric, June 5, 2009



Project: Prehistoric Animal

Creature: Cynodont

Name: Jean Period: 6 Date: 6/5/09

	1 Little	2 Some	3 Average	4 Thorough	5 Excellent	Comments	
Animal Design					X	excellent detail	+1
Materials					X	post study frame	+1
Skin/Color Pattern					X	very good pattern	
Anatomy (x3)					X	A LOT of detail	+1

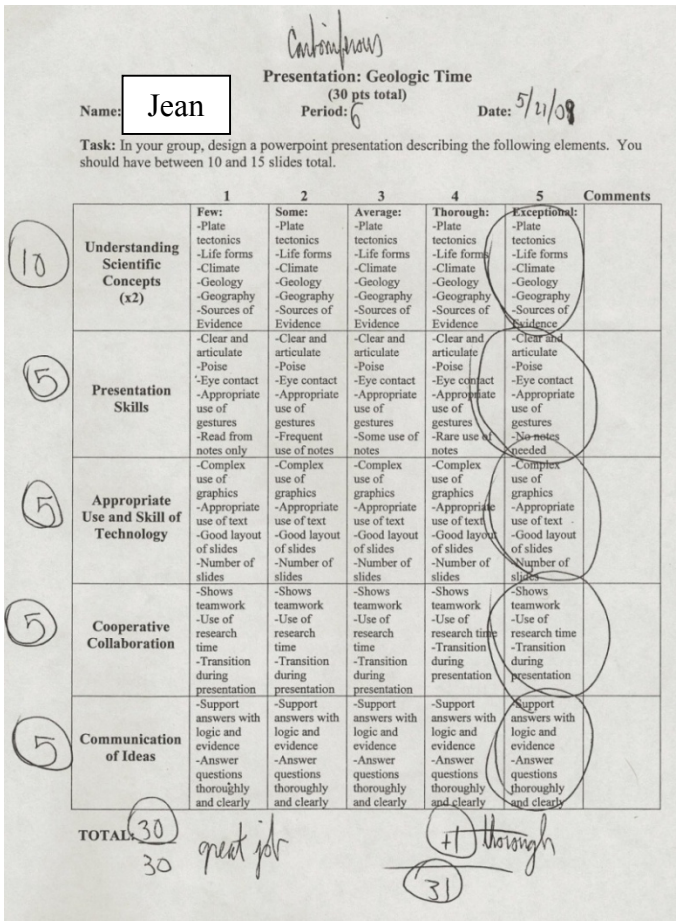
6 6 5 6x3= 18

TOTAL: 35 /30

HUGE! 1 meter long

Figure 2. Jean's cynodont (non-traditional) prehistoric creature project, June 5, 2009

Figure 3. Jean's geologic period group PowerPoint presentation rubric, May 21, 2009



Presentation: Geologic Time
(30 pts total)

Name: Jean Period: 6 Date: 5/21/08

Task: In your group, design a powerpoint presentation describing the following elements. You should have between 10 and 15 slides total.

	1	2	3	4	5	Comments
Understanding Scientific Concepts (x2)	**Few:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Some:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Average:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Thorough:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Exceptional:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	10
Presentation Skills	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Read from notes only	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Frequent use of notes	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Some use of notes	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Rare use of notes	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -No notes needed	5
Appropriate Use and Skill of Technology	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	5
Cooperative Collaboration	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	5
Communication of Ideas	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	5
TOTAL:	30					30 great job

+1 thorough

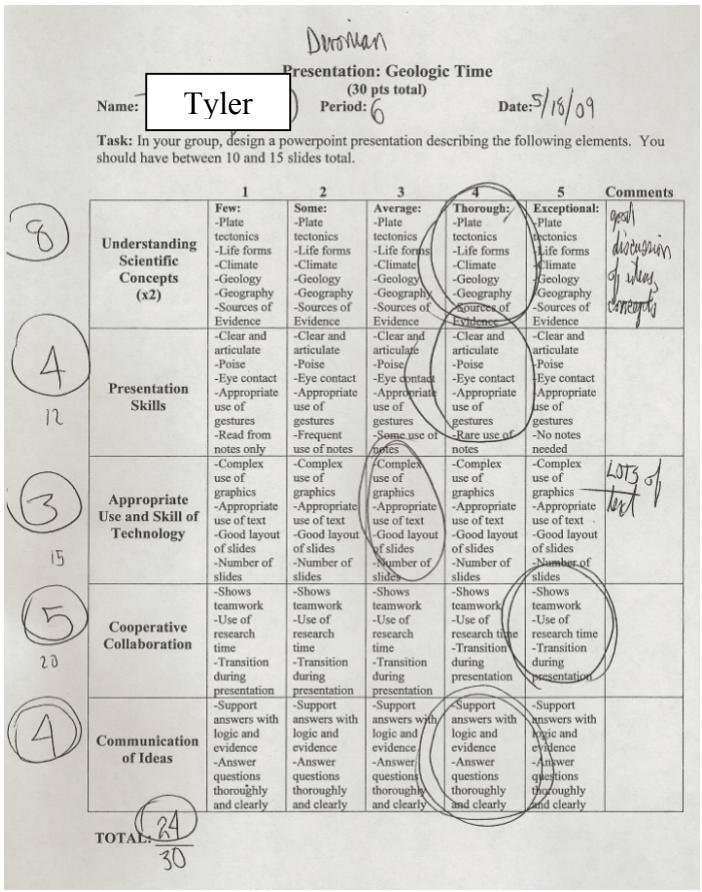
31

Tyler. In spite of limited data sources due to some missing assignments, Tyler also demonstrated a flexible learning style suggestive of competence in both traditional and non-traditional intelligences. He performed best when a broad variety of intelligences were tapped instead of a more defined range; all three data sources supported this interpretation. In addition, he scored extremely high on his intrapersonal field (10 out of 10). When asked how he would prefer to display his learning outcomes, Tyler chose PowerPoint, citing many reasons why:

> Well, it's a synergy of technology and also putting together something your fellow students can understand, like putting it in simple language but also making it visually appealing and trying not to put a lot of text. . . You're presenting information to someone or you're presenting your own thoughts to someone but it's also got visual aspects, and I'm a visual learner. So if I can see something and I can relate some text to a picture, that helps me a lot. I feel fine doing most presentations because compiling it, making it yourself, you know what you're talking about, so I don't feel much pressure because I'm supposed to be the authority. And most of the time, I feel that I *am* because I've studied up and gone over lots of information and sources. (personal communication, June 5, 2009)

As this self-report predicts, Tyler employed numerous intelligences to fulfill a single project (see Figure 4). The logical-mathematical field was used in constructing the slideshow in an orderly, sequential format and in presenting, explaining, and defending his scientific information to the audience. He also employed visual-spatial intelligence in constructing a PowerPoint that was pleasing to the eye by adding appropriate and meaningful graphics to enhance his assignment. During his oral presentation, this adaptable student displayed the good communication skills associated with verbal-linguistic intelligence. Throughout the project, he used his skills in the interpersonal area to work well with his group, while his intrapersonal skills guided and motivated him as an individual who wished to earn high marks for his efforts. Unlike Jean who failed to recognize her numerous talents, however, Tyler seemed to be able to identify his strengths and utilize them to the best of his ability.

Figure 4. Tyler's geologic period group PowerPoint presentation rubric, May 18, 2009



Presentation: Geologic Time
(30 pts total)

Name: Tyler Period: 6 Date: 5/18/09

Task: In your group, design a powerpoint presentation describing the following elements. You should have between 10 and 15 slides total.

	1	2	3	4	5	Comments
Understanding Scientific Concepts (x2)	**Few:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Some:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Average:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Thorough:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Exceptional:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	good discussion of ideas/ concepts
Presentation Skills	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Read from notes only	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Frequent use of notes	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Some use of notes	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Rare use of notes	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -No notes needed	
Appropriate Use and Skill of Technology	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	LOTS of text
Cooperative Collaboration	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	
Communication of Ideas	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	

TOTAL: 24/30

Joan. Joan performed slightly better with traditional than with non-traditional assignments (see Table 1). Overly self-critical, her survey results were very low overall, with the exception of her intrapersonal score (8 out of 10). Unsurprisingly, she seemed to self-report her preferential learning style accurately; both performance and interview data supported her self-assessment.

Table 1. Joan's Performances on Assignments:

Assignment	*Grade*	*Percentage*	**Intelligences*	*Type*
Video Sheets	A	93.8%	LM, VL	Traditional
Scavenger Hunts	C-	73.3%	LM	Traditional
Group PowerPt	D+	66.7%	VS, LM, VL, Inter	Non-traditional
Project 1	D	60%	LM, VL	Traditional
Final Exam	F	38%	LM, VL	Traditional
Quizzes	F	36.1%	LM, VL	Traditional
Worksheets	F	10%	LM, VL, some VS	Traditional
Project 2	F (NHI)	0%		Non-traditional
Lab Write-up	N/A (absent)	N/A	N/A	N/A

*LM= logical-mathematical VL= verbal-linguistic VS= visual-spatial Inter= interpersonal

Joan seemed to struggle with most assignments, regardless of their nature. She performed better on assignments relying chiefly on the logical-mathematical domains, especially those that involved direct, easily accessed answers and concepts; an example was a scavenger hunt worksheet which she could take home to complete without the time constraint of a single class period. Joan did best in filling out her video sheets (questions students answer while watching an in-class video program), perhaps due to their linear-sequential format and the fact that students often assisted each other in answering the questions before turning them in for credit.

Assignments that delved into deeper forms of analysis and those requiring her to memorize facts and concepts, then regurgitate them under a time constraint, were especially difficult for her. She failed the vast majority of traditional quizzes and tests. For example, Joan's performance on her unit exam was extremely poor (the fifth lowest score in the class). Several answers were left completely blank, and she did not even attempt a required essay from a list of topical choices.

Joan's first unit project, a traditional research paper, was largely incomplete, failing to delve deeply into the characteristics of her chosen prehistoric animal. Furthermore, she did not follow standard writing conventions; her paper lacked appropriate citations and a reference page. As a result, she barely passed the assignment. She failed to submit a second (non-traditional) project, citing on her project questionnaire a lack of preparation on her part.

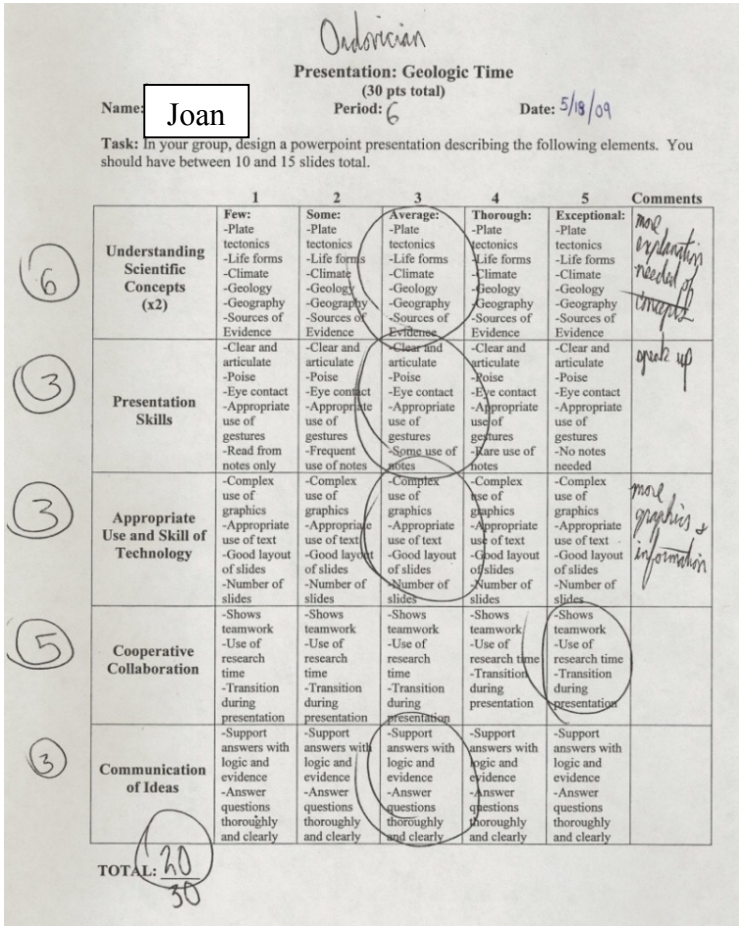
Joan was absent on one of the worksheet due dates. A second one she never turned in. The third one earned a failing grade. Unfortunately, Joan was absent the entire time that the class engaged in the two-day micro-evolution lab activity and, as a result, submitted no report.

Perhaps Joan's struggles were exacerbated by the increased rigor of the Pre-AP class and her difficulties in keeping pace:

> The only class that I'm struggling in with right now is, well, this class, Pre-AP biology. That's because since I just came [from], like, a standard science [class] and I was just, like, I was suddenly on to a higher level of science. . . . Well, I guess you could say that it was how much more work than a regular class would have. In the regular class, you had one, two, maybe even three projects, maximum, while in a Pre-AP, um, class you have, uh, you have approximately a project or two at the same time, like right now, or even one project that's, like, due in a certain time, like, in a week or two. . . . I think it was how much homework or the projects that were given. It was more of the workload . . . I just think that I wasn't ready. Well, I guess you could say that I, well, I wasn't able to process it fast enough. (personal communication, June 11, 2009)

Nevertheless, Joan's group PowerPoint presentation met standards although it could have used improvement, especially in the areas of explaining and communicating key scientific concepts, presentation skills, and slideshow design (see Figure 5).

Figure 5. Joan's geologic period group PowerPoint presentation rubric, May 18, 2009



Ordovician

Presentation: Geologic Time
(30 pts total)

Name: Joan Period: 6 Date: 5/18/09

Task: In your group, design a powerpoint presentation describing the following elements. You should have between 10 and 15 slides total.

	1	2	3	4	5	Comments
Understanding Scientific Concepts (x2)	**Few:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Some:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Average:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Thorough:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Exceptional:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	more explanation needed on concepts
Presentation Skills	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Read from notes only	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Frequent use of notes	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Some use of notes	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Rare use of notes	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -No notes needed	speak up
Appropriate Use and Skill of Technology	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	more graphics & information
Cooperative Collaboration	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	
Communication of Ideas	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	

6 3 3 5 3

TOTAL: 20/30

During her interview, Joan reported that she preferred discovering information on her own to lecture. She would have liked rearrangements of seating so that students did not always aggregate into cliques, and said that she enjoyed audiovisual and presentation formats that allowed her to work with others. Her PowerPoint assignment, although earning a rather low score, proved to be one of her highest performances.

Analysis. From the student data available, as illustrated by these three primary subjects, I constructed the following finding.

> *Assertion One*: Some students in my classroom possessed a deeper intuition regarding how they were best able to demonstrate their learning outcomes through a variety of different educational opportunities and, as a result, were better able to demonstrate their academic achievement by choosing types of assignments that focused on these intelligences.

Students like Tyler and Joan seemed to have better intuition in identifying their preferred strengths. Students like Jean, who showed limited self-awareness, either were less able to identify successfully their inherent cognitive strengths or less willing and confident to strike out beyond their perceived stronger intelligences. Even for students who did not know their own MI strengths, my application of MI theory provided a powerful key for revealing their actual achievements: varying the types of performance tasks and allowing students to pick and choose as well as to experiment with different ways to demonstrate their achievement.

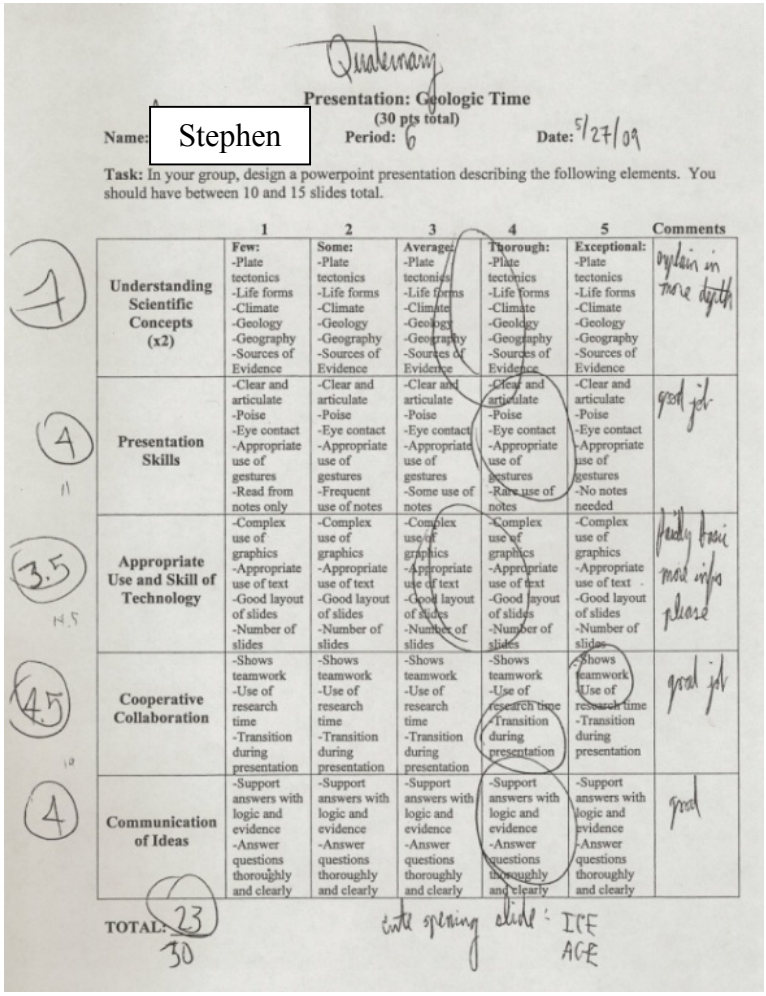
For example, although Jean did not accurately self-report her strengths, she did demonstrate flexibility through varied performances outcomes. Through offering differentiated assignments drawing on various intelligences, Jean was able to show versatility not otherwise acknowledged and perhaps unknown to both student and teacher. Despite her preference for traditional means to exhibit her achievement (primarily through essays and tests), she consistently demonstrated the ability to adapt and utilize other intelligences to fulfill assignment requirements to a high standard.

Aside from her phenomenal cynodont model (kinesthetic domain) and exemplary PowerPoint presentation (interpersonal, visual-spatial, and verbal-linguistic domains), Jean wrote an excellent research paper describing the sources of evidence for evolutionary theory, receiving thirty-four out of thirty points due to exceptional supporting details, in-depth analysis, use of graphics to enhance her paper, and expansive collection of fourteen references. She was also an excellent writer, despite her self-reported mediocre score in this intelligence (5 out of 10).

Tyler also showed capacity in unacknowledged areas of intelligence. Although he disliked hands-on activities, he openly appreciated the opportunity to expand his range because of the assignment options available to him: “So, like the molecule building was . . . was one of my favorites, but. . . but it was different. It let me experience something sorta new and let me test myself” (personal communication, June 5, 2009).

Another primary subject, Stephen, seemed to under-rate his skill in the visual-spatial realm (scoring 2 out of 10) when compared to his performance on two assignments relying heavily on this domain, both of which were classified as non-traditional. He proved quite adept at using and manipulating graphics, especially those on his PowerPoint presentation (see Figure 6) and prehistoric food web (see Figure 7). Although he seemed to recognize his kinesthetic strengths, Stephen, a non-traditional learner, appeared to underestimate his visual-spatial abilities.

Figure 6. Stephen's geologic period group PowerPoint presentation rubric, May 27, 2009



Quaternary

Presentation: Geologic Time
(30 pts total)

Name: Stephen Period: 6 Date: 5/27/09

Task: In your group, design a powerpoint presentation describing the following elements. You should have between 10 and 15 slides total.

	1	2	3	4	5	Comments
Understanding Scientific Concepts (x2)	**Few:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Some:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Average:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Thorough:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	**Exceptional:** -Plate tectonics -Life forms -Climate -Geology -Geography -Sources of Evidence	explain in more depth
Presentation Skills	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Read from notes only	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Frequent use of notes	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Some use of notes	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -Rare use of notes	-Clear and articulate -Poise -Eye contact -Appropriate use of gestures -No notes needed	good job
Appropriate Use and Skill of Technology	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	-Complex use of graphics -Appropriate use of text -Good layout of slides -Number of slides	pretty basic need info please
Cooperative Collaboration	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	-Shows teamwork -Use of research time -Transition during presentation	good job
Communication of Ideas	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	-Support answers with logic and evidence -Answer questions thoroughly and clearly	good

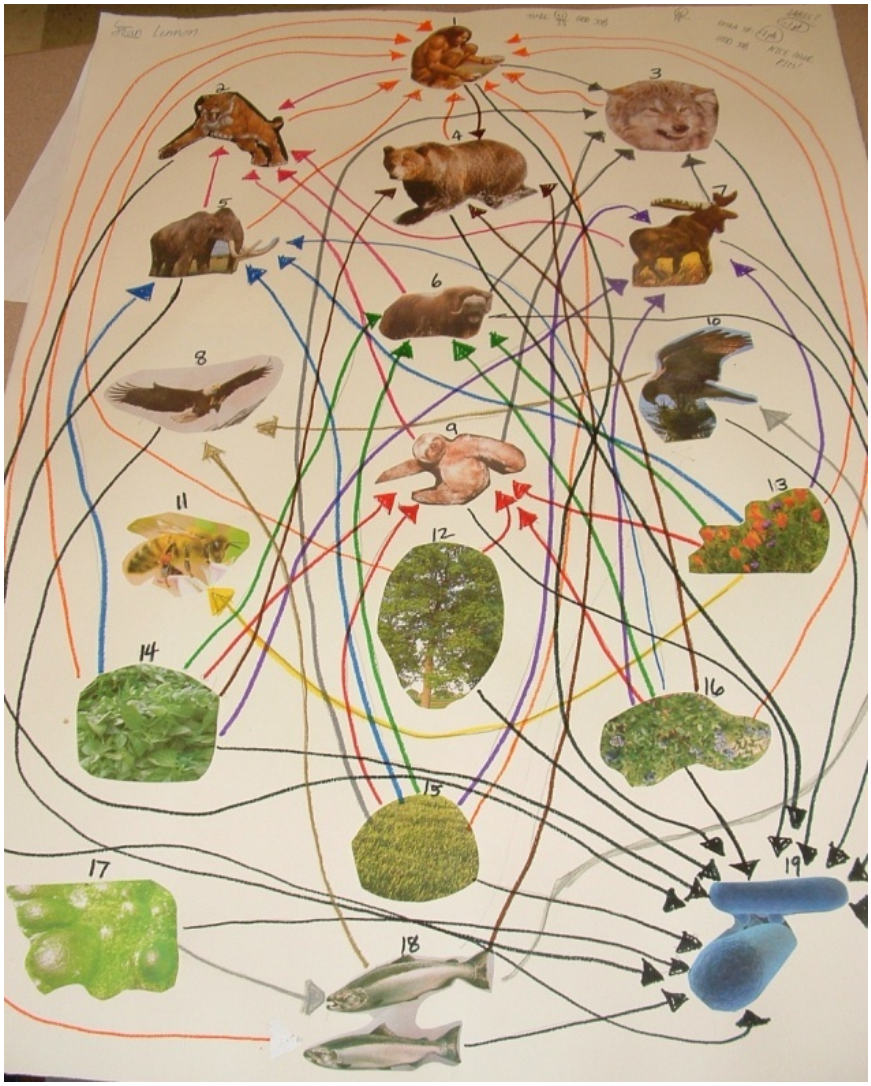
TOTAL: 23/30

title opening slide: ICE AGE

Stephen's prehistoric food web earned him high marks for its creative design, thoroughness, complexity, and vivid pictures. His accompanying essay successfully explained the relationships of the prehistoric organisms on his posterboard. This assignment was Stephen's highest scoring performance of the entire unit. When asked why he was successful on these types of projects, he offered the following rationale:

> Because it's a big project. And it's not like your regular worksheet where you, like, . . . you had to find out what it is and what it means. You actually had to, like, research into it and find out which animals were in that time instead of just, like, slapping something together. (personal communication, June 8, 2009)

Figure 7. Stephen's Prehistoric Food Web (Quaternary Period), June 12, 2009



By contrast, David completed in-class tasks that did not require him to do outside work, but most assignments to be completed at home were either insufficiently completed or not handed in for credit. As a result, traditional assignments favoring the verbal-linguistic and logical-mathematical intelligences, which were more likely to be targeted by in-class work, suggested (perhaps falsely) relative strength in these two areas of intelligence.

Although limited data due to his numerous missing assignments interfered with analysis, David seemed stronger in more traditional intelligences (see Table 2). He was a very flexible learner and utilized numerous intelligences with relative ease. He self-reported mediocre skill in the verbal-linguistic domain and disliked literature, yet was amazingly articulate, wrote nicely (and with beautiful penmanship), and performed well on all those tasks he submitted. Surprisingly, he did not score favorably on his presentation, and I suspected he had not adequately prepared for this assignment.

Table 2. David's Performances on Assignments

Assignment	*Grade*	*Percentage*	**Intelligences*	*Type*
Quizzes	B-	81.7%	LM, VL	Traditional
Final Exam	C+	79.3%	LM, VL	Traditional
Group PowerPt	D+	66.7%	VS, LM, VL	Non-traditional
Video Sheets	F	56.4%	LM, VL	Traditional
Scavenger Hunts	F	30.9%	LM	Traditional
Worksheets	F	26.3%	LM, VL, some VS	Traditional
Lab Write-up	F (missing)	0%	VS, LM, VL	Traditional
Project 1	F (missing)	0%	LM, VL	Traditional
Project 2	F (missing)	0%	VS, LM, K	Non-traditional

*LM= logical-mathematical VL= verbal-linguistic VS= visual-spatial K= kinesthetic

Student-Selected Assignment Options

The range of my students' preferences and skills made clear the importance of varying types of assignments for two main reasons. First, a range of assignments broadened my students' opportunity to draw on their strengths, expanding beyond the traditionally assessed two, logical-mathematical and verbal-linguistic intelligences. The variety of assignment options reduced the marginalization of students who were not strong in these two intelligences. Second, by differentiating assignment options, students were required to delve into domains they otherwise would not have experienced. This had the effect of allowing them to identify and strengthen hidden aptitudes.

Offering differentiated performance tasks to use MI theory was a way to enhance the validity of inferences and actions based on assessment results. This strategy supported each student's unique MI profile and is at the heart of individualizing education. Varying assignment options had the additional benefit of supporting initiative and autonomy by granting each individual the opportunity to make choices that drew upon his or her representative strengths. By allowing students to draw upon their representative strengths, I was able to draw more informed conclusions about their learning and minimize the effects of rival constructs, thereby enhancing my ability to derive valid inferences about their academic achievement.

In spite of her mediocre verbal-linguistic score (5 out of 10), Jean certainly shined on tasks requiring her to express herself in writing through logic and reasoning (a self-score of 9 out of 10) as demonstrated by her quiz and test scores (see Table 3). Time and again, she performed extremely well on a wide range of activities, all of which required, to some degree or another, the use of the logical-mathematical domain.

"I do really good on the tests," she claimed during her interview. When asked to explain why tests best measured her potential, she added, "I think a test pretty much accurately does that because I'm given the ability to study for it and things like that, as opposed to a project where it just like builds up over time . . . They're an overall view of what the chapter was and what you should know," Jean later clarified (personal communication, June 9, 2009). Performance tasks such as tests and quizzes that targeted the logical-mathematical intelligence permitted Jean to demonstrate her scholastic ability the most. As a result, she was better able to exhibit the best products possible from her extensive range of skills, and I, in grading her work, could more clearly conclude that she had met or exceeded standard.

Table 3. Jean's Quiz/Test Scores

Assignment	*Points Earned/Total*	*Percentage*	*Grade*
Origins 1	10/10	100%	A
Origins 2	10/10	100%	A
Origins 3	7/10	70%	C
Origins 4	9.5/10	95%	A
Origins 5	9/10	90%	A-
Geologic Time	19.5/20	97.5%	A
Evolution 1	9/10	90%	A-
Evolution 2	10/10	100%	A
Total Quiz Scores	84/90	93.3%	A-
Final Exam	68/75	90.7%	A-

When probed why she would pick writing an essay over another option, Jean's reply indicated that an essay would provide a more valid reflection of her achievement, her understanding of a topic, as opposed to a demonstration of her research ability:

> It's all of what I know . . . Like, say you had us do a research paper, then . . . I might know most of the information, but I still would be able to go in and look it up like in books or online. And then, um, if I had to look it up, then it defeats the purpose of what I know versus what I ended up finding out. . . . I can explain what I know in great detail in an essay and go on lots of elaboration. (personal communication, June 9, 2009)

Jean's insightful answer showed that she understood that constructing an essay by herself from her requisite knowledge base, avoiding the rival construct of what she is able to cobble together from other sources. In this vein, a written essay let this student

demonstrate her own knowledge through careful elaboration and articulation of key scientific concepts.

Joan, too, preferred to demonstrate her learning through written format: "I'd probably go with a research paper or some kind of essay paper." When asked why, Joan replied, "A couple of reasons, actually. Um, the other projects, I'm not too fond of building or what not." Later on she added the following reason:

> I just find it easier to just type up a regular paper instead of building. . . I just, I haven't, like, I haven't really done much building projects. I've done more written essays, those kind of things, before. So, I'm not really effective or grounded in it. (personal communication, June 11, 2009)

Joan's interview confirmed the results from her self-scored MI questionnaire in which she reported higher her logical-mathematical (6 out of 10) and verbal-linguistic (4 out of 10) intelligences than kinesthetic intelligence (2 out of 10). The difference in her self-scores in these domains also suggested that she would prefer written assignments over hands-on activities to better demonstrate her achievement.

On the other hand, Anton struggled with tasks relying chiefly on the linguistic expression (both written and verbal) of scientific concepts. He performed better on the geologic timeline assignment which allowed him to draw upon his visual-spatial and kinesthetic abilities (see Figures 8-9). During his interview, he explained:

> I think it's the out-of-class projects [that let me demonstrate my learning potential] because it really shows how I, uh, can put what I've learned on to, like, a visual where I can explain. It can clearly show what I remember, and what I studied, and what I learned. . . . I decided to do a timeline because, for my latest project, for the geologic timeline, because that showed that I had what I needed. I knew that section for that chapter. . . . I knew every detail. (personal communication, June 10, 2009)

Anton seemed to understand that his kinesthetic and visual-spatial intelligences allowed him to demonstrate his academic achievement better than any other intelligences allowed. By drawing upon his strengths, Anton was able to show and explain what he had learned in class to the best of his ability. An evaluation of his work led me to the conclusion that Anton had met, and even surpassed, all the necessary criteria as outlined on the rubric.

Figure 8. Anton's Geologic Timeline, June 10, 2009

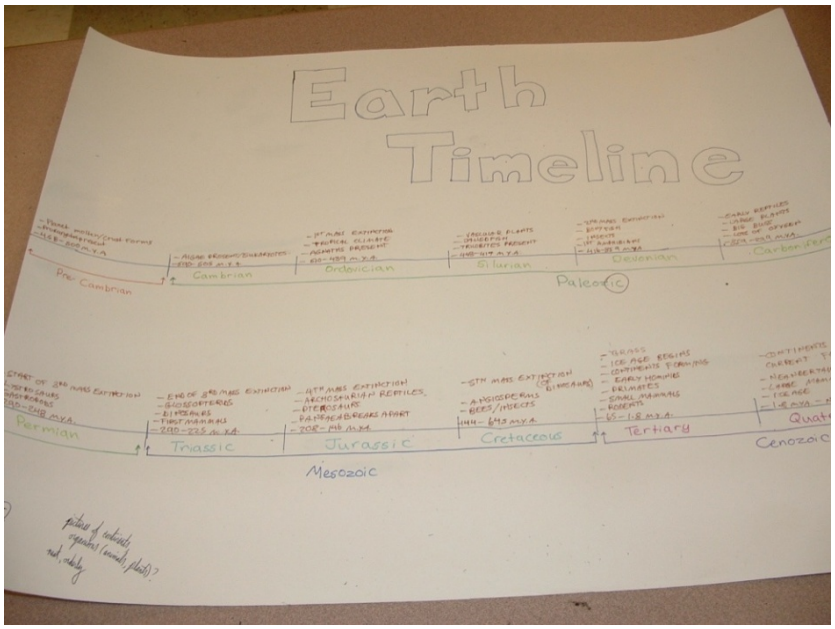


Figure 9. Anton's Geologic Timeline Rubric, June 10, 2009

Anton

P.6

6/10/09

Project: Earth's Geologic History
(30 points)

Construct a geologic timeline of the Earth's history on posterboard, starting with the formation of our planet during the Pre-Cambrian Period and ending with present day in the Quaternary Period. You will have to determine the scale for each Period and mark it on your posterboard. Accurately represent the length of time on your project (some periods last longer than others). For each Period, list the dominant plants and animals living at that time on Earth. You may either sketch and draw on your posterboard or cut out pictures of these life forms. Furthermore, list any major events that occurred during our planet's development (including the 5 major mass extinctions). Your grade is determined by your scientific accuracy, the neatness and organization of your project, and the abundance of information provided.

The following periods must be placed in order on your posterboard:

Pre-Cambrian Period, Cambrian Period, Ordovician Period, Silurian Period, Devonian Period, Carboniferous Period, Permian Period, Triassic Period, Jurassic Period, Cretaceous Period, Tertiary Period, Quaternary Period

Criteria	None	Very little	Little	Poor	Below Average	Average	Above Average	Good	Very Good	Excellent
Neatness Organization	1	2	3	4	5	6	7	8	9	10
Scientific Accuracy	1	2	3	4	5	6	7	8	9	10
Thoroughness of Scientific Information	1	2	3	4	5	6	7	8	9	10

- need graphics, pictures
- neat & orderly
- good use of color coding
- erase pencil marks
- perhaps more data, depth needed

26
30

His other project, however, a written research paper focusing on Charles Darwin, earned a failing grade, primarily due to its incomplete nature and lack of depth. Anton elaborated on what his perfect type of assignment would be:

> For me, it'd be something to do with my hands, . . . just anything that actually [you] do – not just sit and listen – through a more visual and more, like, how do you call it – kinetic? – learning, where I can do something that helps me remember. (personal communication, June 10, 2009)

Anton's self-report on his MI questionnaire was triangulated with both interview and performance data. He self-scored both his verbal-linguistic (2 out of 10) and logical-mathematical (6 out of 10) intelligences lower than his kinesthetic (9 out of 10) and visual-spatial (8 out of 10) intelligences. For this student, it seemed that hands-on activities and assignments allowed him to better exhibit his academic achievement than other options.

In direct contrast, Tyler explained his personal dislike for kinesthetic activities: "I'm absolutely terrible at building stuff. . . I've never been really good with my hands." Instead, he preferred essays to any other option "because it's just something I do pretty well. Like, especially for factual things, I just get a lot of factual information together and if I just look through that and compile the information" (personal communication, June 5, 2009).

Tyler failed to submit the first unit project but the second project, a research paper on Jane Goodall, earned 22 out of 30 possible points. It was written rather well, but lacked citations and an explanation how her research contributed to our understanding of human origins. Much to my pleasure, Tyler did very well on the unit final exam, scoring 62.5 out of 75 points total, the third highest grade in the entire class. Undoubtedly, Tyler's strengths in the logical-mathematical and verbal-linguistic came into play at that critical moment. Consequently, Tyler's academic achievement, as represented by his linguistic work, enhanced my ability to make informed, valid inferences about what he knew.

Although he demonstrated a wide array of talents, David did best on in-class assignments targeting his strengths in logic and expression – in spite of an average self-reported verbal-linguistic score. He was one of the few students whose quiz and test scores were relatively high (see Table 4). His greatest challenge was meeting long-term deadlines. My gradebook recorded numerous "NHI" (not handed in) scores, mostly from projects or assignments requiring out-of-class effort. In-class assignments showed high scores reflecting his logical-mathematical intelligence (for instance, his quizzes and final exam). In fact, his final exam score was the fifth highest in the class even though his overall class ranking was 17 out of 26. When asked about his high quiz scores, David explained:

> I'm pretty good at remembering things, so when a quiz comes up, I can usually draw back to what I've learned, pull it back up, and touch on that. I think I do a lot better, actually, under pressure . . . because, if I'm given a lot of time to do

something, I just kinda procrastinate on it. (personal communication, June 12, 2009)

David's achievement was best demonstrated by in-class measures that focus on his logical-mathematical intelligences where rival constructs (e.g., lack of focus or time management) were minimized. As a result, I could determine his academic achievement more accurately by assessing his quiz and test scores.

Table 4. David's Quiz/Test Scores

Assignment	*Points Earned/Total*	*Percentage*	*Grade*
Origins 1	9/10	90%	A-
Origins 2	9.5/10	95%	A
Origins 3	10/10	100%	A
Origins 4	8/10	80%	B-
Origins 5	8/10	80%	B-
Geologic Time	10/20	50%	F
Evolution 1	10/10	100%	A
Evolution 2	9/10	90%	A-
Total Quiz Scores	73.5/90	81.7%	B-
Final Exam	59.5/75	79.3%	C+

Stephen, however, did better on tasks allowing him to draw upon his kinesthetic skills as seen with his two high-scoring, non-traditional assignments: prehistoric food web, group presentation (see Figures 6-7). He struggled with those assignments that relied primarily upon the verbal-linguistic and logical-mathematical domains, both of which were his weak points (see Tables 5-6). Like so many other students, Stephen's academic achievement was best measured by evaluating the work he produced by tapping into his strongest intelligences. He better exhibited what he had learned in class by constructing products than by assessments that relied chiefly upon written and explanatory modes.

Table 5. Stephen's Quiz/Test Scores

Assignment	*Points Earned/Total*	*Percentage*	*Grade*
Origins 1	2/10	20%	F
Origins 2	8/10	80%	B-
Origins 3	4/10	40%	F
Origins 4	5/10	50%	F
Origins 5	5.5/10	55%	F
Geologic Time	10/20	50%	F
Evolution 1	8/10	80%	B-
Evolution 2	3.5/10	35%	F

Total Quiz Scores	46/90	51.1%	F
Final Exam	46/75	61.3%	D

Table 6. Stephen's Project Scores

Assignment	*Points Earned/Total*	*Percentage*	*Grade*
Prehistoric Food Web	31/30	103%	A
Geologic PowerPt	23/30	76.7%	C+

Differentiated options allowed my students to show better and more clearly what they had learned in my science class. Each student could draw upon his or her unique intelligence profile to produce work that better reflected individual academic achievement. In this way, I was better serving the needs of my students on a personalized level and could make more valid inferences about individual success.

During interview, a few students confirmed the benefits for variation in classroom assignments. While Tyler acknowledged that "there are so many different types of evaluations of our knowledge" (personal communication, June 5, 2009), Joan explained why teachers should give students a variety of assignment options, recommending:

> Don't rule a classroom, or don't be so strict on your classroom or your students that they, I won't say necessarily say *rebel*, but be so bored of your class that they are failing because you're just giving them worksheets, or a packet, and they don't turn them in, or to give long lectures for one whole class period. (personal communication, June 11, 2009)

On the basis of the data I collected and analyzed, I developed a second finding as follows.

> *Assertion Two*: Varying the types of assignments in accordance with MI theory improved the validity of inferences about my students' academic achievement. My students' abilities to demonstrate their achievements were best exhibited through their respective MI strengths. This was true for both high- and low-achieving students. However, offering differentiated performance tasks was most critical for my non-traditional students since they struggled most in a traditional classroom environment.

Multiple Intelligences and Behavioral Traits

MI theory may also shed light on the reason why some students are better suited to traditional classroom environments than are others. During the course of data analysis, I noticed that many of my highest achievers also self-reported low interpersonal domains. I began to wonder if there was a correlation between certain intelligences and student preferences or behavioral characteristics. For instance, throughout the entire course and unit, Jean consistently maintained the highest grade in class. She, along

with the other two highest-ranking students (one male, one female), all self-reported extremely low interpersonal scores (1-2 out of 10). The other two also self-reported mid-range to high scores in the intrapersonal domain (6-7 out of 10), while Jean rated herself 1 out of 10 intrapersonally. By contrast, the three lowest academic performers self-scored mid-range to high ratings in the same intelligences. I considered the contrast evidence of the relative immunity of the high achievers to social distractions. When Jean reported that group projects failed to measure her learning potential, she explained an actual aversion to assignments requiring interpersonal skills:

> In a way, it's almost like a cumulative of everybody in the group and, uh, sometimes, one person will work on it more so than, like, all the other people in the group. So it's kinda like you're sharing one person's overall work, instead of each person doing something on their own. (personal communication, June 9, 2009)

In stark contrast to Jean's dogged determination to maintain academic excellence, David, although quite capable, proved frustratingly difficult to evaluate due to persistently missing work. Over the course of the unit, he failed to hand in ten different assignments. I begin to wonder if this outcome was the product of lack of engagement due to the traditional nature of the assignments. When probed about the cause, he offered the following explanation:

> Uh, yeah, long-term projects . . . nah . . . sometimes I just forget about 'em, and then, like, I get reminded – but it's, like, to write down or sign up for what I wanted to do. Then I remember, like, the week of or a few days before, and then it's kinda too late. (personal communication, June 12, 2009)

Four students in the class, two males and two females, who failed to turn in eight, eight, twelve, and seventeen assignments, respectively, all self-reported high scores in both in the kinesthetic and interpersonal domains. In fact, these two intelligences displayed more consistent scores (7-9 range) than any others among student MI profiles. I surmised that perhaps traditional teaching, relying heavily on paper and pencil tasks and lecture style, failed to cultivate motivation or interest in these students who were more inclined to learn with interactive or hands-on activities. It seemed reasonable that these same students would be potentially more stimulated by collaborative activities but also more easily distracted by them, in comparison to the more isolating traditional assignments. Interestingly, of these very same students, three of them sometimes had very high intrapersonal scores (see Tables 7-8).

Table 7. MI Profile Trends and Missing Assignments

Name	*Gender*	*NHI's*	*Kinesthetic*	*Interpersonal*	*Intrapersonal*
David	Male	10	7	7	8
Houston	Male	8	9	8	9
Jessica	Female	8	9	8	2
Pedro	Male	17	8	7	1

Karen	Female	12	9	9	8

Table 8. Number and Type of Missing Assignments

Student	*Video*	*Scav Hunt*	*Quiz*	*PowerPt*	*Worksheet*	*Lab*	*Project 1*	*Project 2*	*Total*
David	2	3	0	0	2	1	1	1	10
Houston	0	4	0	0	1	1	1	1	8
Jessica	0	3	0	0	2	1	1	1	8
Pedro	4	4	2	1	3	1	1	1	17
Karen	2	3	3	0	1	1	1	1	12

MI contributed to plausible explanations as to why these five students frequently failed to turn in assignments. Some complained that videos shown in class moved too quickly, leaving them too little time to respond adequately in writing. As a result, some students gave up entirely instead of exercising the option of collaborating with their peers. Although, to my knowledge, none of the students in the subject pool were English Language Learners, any students who struggled in the verbal-linguistic domain would find this type of task particularly difficult. Pedro, Jessica (scoring 2 out of 10), and David (scoring 5 out of 10) failed to turn in the most of these types of assignments, and might have encountered such a struggle. Karen (scoring 8 out of 10) and Houston (scoring 10 out of 10) counter-indicated this interpretation.

Scavenger hunt worksheets, assigned as homework to be completed in one to two days, typically fell within the logical-mathematical domain. They were the most common type of assignment that these five students did not hand in for credit. One potential reason was that these assignments forced students to seek out answers for themselves instead of merely copying answers down, and required students to read carefully the clues given and to exhibit initiative to complete these tasks. Students who lack motivation are not likely to turn in such assignments for credit. All of these students failed to hand in several worksheets, the second most common type of assignment not turned in; one student did not turn in any of them. There were three such worksheets in this unit, all to be completed at home. The tasks focused mainly on the logical-mathematical domain, while calling for verbal-linguistic and occasional visual-spatial skills also. Correlating these missing assignments with students' self-reports of intrapersonal and logical-mathematical skills, I found that only Jessica and Pedro self-reported low ratings in these intelligences; the other three students ranked moderate to high in these two areas.

Although quizzes were in-class assignments, two students failed to turn them in nonetheless. These minor assessments largely targeted the logical-mathematical domain, measuring students' comprehension of scientific concepts, and also the verbal-linguistic domain in requiring students to explain and discuss their understandings in written form.

Only one student failed to turn in the PowerPoint presentation assignment. Students were allowed to choose their own groups and time periods and were given two days in the library to conduct research and construct their respective slideshows. Pedro failed not only to sign up with a group but also to demonstrate any initiative to join one when prodded to do so. When groups presented, he did not budge from his seat. As a result, he earned a zero for the assignment. I can only guess why this was the case; he seemed to have a good rapport with his classmates, socializing with them and occasionally joking with his friends. In his MI questionnaire, Pedro even self-reported a high score of 7 in the interpersonal domain. Working alone, this student struggled with keeping pace in the class and consistently failed to turn in assignments or prepare for the rigors of class.

There was only one lab report in this unit that students were to turn in for credit. The lab exercise ran two days during class and modeled evolution at work, with students taking on the role of predator and competing with their classmates to survive into a subsequent generation. The simulation was extremely kinesthetic, but the recording of results was very logical-mathematical. The actual lab report and analysis targeted this intelligence along with the verbal-linguistic (for explanation of results) and visual-spatial (for graphing results) domains. All of these five students failed to turn in this assignment. However, it is worth noting that this due date fell towards the end of both the unit and our semester with finals looming on the horizon, a confounding variable. Bearing this in mind, I even allowed a resubmission for credit, yet none of these students took advantage of that extension.

There were two unit projects, one targeting the origins of life and geologic time, and the other focusing on evolutionary theory. Students were allowed two and three weeks to submit their respective choices from a long list of potential options. Students had to pick one project that drew mainly on the logical-mathematical and verbal-linguistic domains, while the second had to be non-traditional in nature, using the other intelligences. All five of these students failed to hand in any of their respective projects, even those in their preferred domains. I was baffled by this result and quickly constructed open-ended questionnaires asking all students why they chose their two project options and, if they failed to submit a project, the reason why.

David reported that he started his first project but found out the *Smilodon* was not a species, but rather a genus (he never requested assistance to clarify this issue). For the second project, he wrote that he was working on the first project, got blindsided, and forgot about it entirely. Jessica offered as reasons that she had been very busy with other classes and failed to turn in the first project. She said she had left her second project at home and failed to turn it in thereafter. Houston stated that he lacked money to gather materials to construct the first project and that he repeatedly forgot to do the other while also lacking motivation to work on it. Pedro and Karen did not even fill out the questionnaire. Failure to submit assignments may be the product of student inability to access the requisite intelligences necessary to complete these tasks. Moreover, many non-traditional students are particularly at risk since several of their intelligences may not be ordinarily utilized.

All but one of the primary subjects self-reported high scores in the intrapersonal domain; only Jean, the leading student, judged herself to be low in this realm (see Table 9). I found this to be a significant correlation. Of further interest was the realization that, of these seven students, only the three high-achieving members self-evaluated themselves low with respect to the interpersonal field. The other four self-scored very highly. In essence, these four students appeared balanced between the interpersonal and intrapersonal intelligences.

Table 9. MI Profile Trends and Work Ethic

Name	*Gender*	*NHIs*	*Interpersonal*	*Intrapersonal*	*Unit Rank*	*Unit Grade*
Jean	Female	0	1	3	1	96%
Olga	Female	0	1	7	2	89%
Ray	Male	0	2	6	3	87%
Marina	Female	0	9	8	4	82%
Angela	Female	0	10	10	6	73%
Emma	Female	0	8	8	8	66%
Serena	Female	0	8	8	9	66%

Students with similar MI profiles demonstrated similar behavioral patterns and, therefore, common academic profiles and outcomes. Multiple intelligences may shed some light onto the behavior patterns they exhibited in my classroom. I noted that there was an observable positive correlation between high self-scores in many non-traditional intelligences and resulting poor academic outcomes. For instance, those students who were at the top of the class were often those who prized independence and self-reliance over teamwork and collaboration, perhaps not wishing to have their grade held hostage by others. In contrast, other students preferred working collectively to tackle problems and may have had difficulty grasping abstract concepts by themselves. Additionally, motivation could have been a product of interest. Students whose intelligences are often not utilized (especially those classified as non-traditional) or sidelined in favor of others (e.g., logical-mathematical and verbal-linguistic) might well choose not to complete assignments due to feelings of apathy or lack of inclusion. This could be especially true of students who are extremely social or who have not yet developed self-control and maturity.

At the end of the unit and school year, the entire class was surveyed for their collective perspectives about the class. Although the questionnaire was designed for multiple purposes, not all pertaining to this research design, two closed Likert-style items and four open-ended, constructed-response items asked for student opinions with respect to the research question as follows:

Question 3: Mr. Galvas helps me to learn by incorporating different teaching strategies such as lecture, demonstrations, pair share activities, small group work, and individual tasks.

Question 4: Mr. Galvas uses different ways to measure my learning through written essays, tests and quizzes, project-based learning, laboratory assignments, and classroom presentations (survey items, June 15, 2009)

Student responses are represented on the following graphs (see Figures 10 and 11).

Figure 10. Student Classroom Survey Response to Question 3

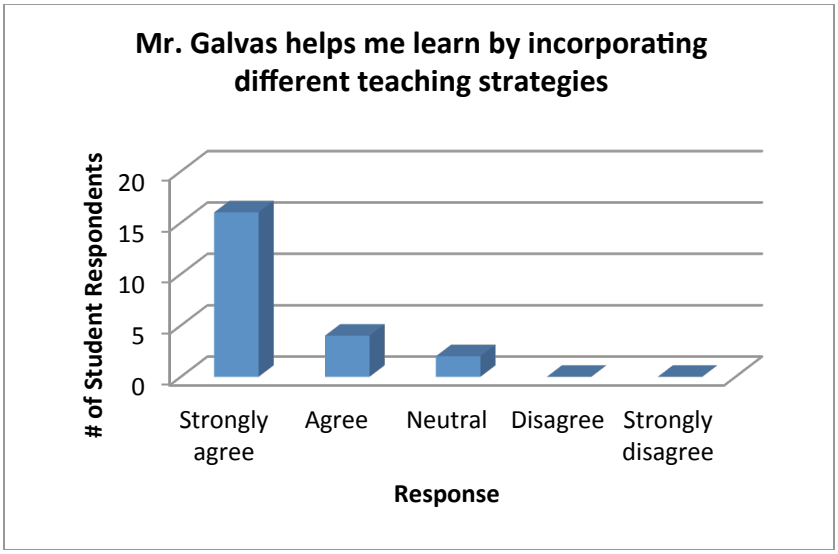
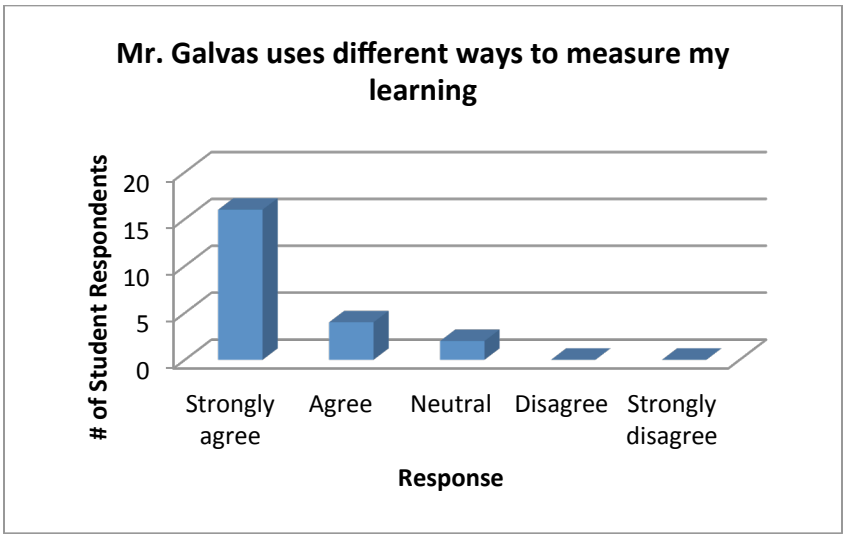


Figure 11. Student Classroom Survey Response to Question 4



The majority of students strongly agreed with both questions 3 and 4, supporting the notion that they approved of differentiated means of instruction and assessment as modeled in the unit. If anything, survey responses reflected the varied and differentiated natures and needs of the students. No two students responded exactly alike, and therefore, each individual required a slightly unique recipe for academic success. I concluded that, although it is logistically implausible to meet the needs of each and every student each and every day of classroom instruction and assessment, by offering a multiplicity of performance outcomes that targets the array of intelligences, teachers may be able to better serve their students' needs.

The open-ended survey items indicated that most students (n=11 of 15) favored non-traditional assignments targeting the kinesthetic and visual-spatial intelligences to those targeting the traditional intelligences, the verbal-linguistic and logical-mathematical domains. Most respondents stated that such preferred activities were fun, easy to understand, or easy to create. The majority of students (n=11 of 15) also cited these same types of non-traditional assignments as best allowing them to demonstrate their learning potential because they permitted students to conduct research in greater depth and were more enjoyable (motivating). A total of ten out of sixteen considered the least favorite assignments to be those of a traditional nature such as quizzes, tests, research papers, and essays. Students did not feel prepared or adept at these tasks and also found them boring. Finally, in terms of students' recommendations for class improvement, some students (n=5 of 15) believed little to no improvement was required. The rest of the respondents offered various suggestions, including more hands-on activities and less class discussion, more class discussion, more student preparation, better concept explanation, increased time to prepare for tests and to finish projects.

Conclusion

Students are complex amalgams of skill sets, each exhibiting a continuum of abilities. There is seldom a clear-cut delineation between one intelligence and another. Rather, each pupil is a constantly evolving, shifting range of cognitive talents, much like the ebb and flow of a tide across a beach. One moment, he or she may prefer one type of task; the next moment, that may change. Students are also often completely unaware of the hidden, untapped capabilities of their minds and can perform unexpected feats when given the opportunity. Like most of us, students prefer to remain in their secure domains and resist venturing into the unknown realms of their underdeveloped intelligences, yet, as their teachers, we should persuade them, and even ourselves, to delve into these other domains. Through trial and error, students may develop not only greater self-awareness of their latent talents, but also hone less perfected skills that might otherwise atrophy. Gardner's multiple intelligences theory is a powerful paradigm that offers teachers an added arrow for their educational quivers to reach and educate a greater number of their students while also delving into the rich uniqueness of the individual.

My research showed that MI can also help teachers more validly assess what their students' have learned, that Gardner's multiple intelligences theory can find practical

application when teachers adapt their assessment strategies to include more intelligences. This benefits many students, especially those who normally fall outside the range of traditional techniques focused on logical-mathematical and verbal-linguistic intelligences. MI can stimulate student learning, reduce the number of missing assignments, and offer a wider range of performance tasks. For instance, kinesthetic learners prefer hands-on, interactive assignments where they create, build, construct, and model their learning outcomes. Collaborative assignments where all group members complete a product (for instance, a PowerPoint presentation) target the interpersonal student.

Gardner himself does not expect teachers to adapt their curricula for each intelligence on a daily basis but, rather, to explore the variations of their students' actual intelligences. By offering a wider sample of performance tasks spanning these intelligences over time, teachers will better serve and honor the individuals they instruct. This may challenge teachers to try new and inventive strategies, as I tried to do, and even venture into their own underdeveloped intelligences. However, I found that the rewards for students, and even for the development of the teacher's professional craft, can be great.

In my research, I have begun to explore my students' range of capacities and to expand the types of intelligences I normally assess in my evaluations of student achievement. Although my journey into MI theory is still developing, it is my hope to become a master archer so that I might better serve my student's needs and respect their respective profiles. I continue to refine project lists as my own understanding evolves and my teaching experience grows. Importantly, my students are allowed to offer alternative options to demonstrate what they have learned, especially in areas in which I consider myself limited (e.g., musical intelligence). Other, equally interesting research avenues remain largely unexplored due to time constraints. I began to notice some unifying trends between student gender and intelligence profiles as well as correlations between student ethnicity and profiles, too. Perhaps further investigation into these domains will yield greater insight between Gardner's theory and demographic data that may aid in better educating students.

Jefferson had it only partly right in his declaration: yes, we all have the right to legal and political equality, but the intelligence profile of each person is unique, as my student, Anton, understood:

> Everyone is different. People learn in different ways and, in this class . . . we do a lot of projects that involve working, like making things. And visually, uh, our teacher – you – will draw something on the board for us, or you'll give us lectures for the people that hear and remember, and we watch movies and write things down . . . You do that to help us remember. (personal communication, June 10, 2009)

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Appendix A
Multiple Intelligences Self-Survey

Instructions: Read each statement below very carefully. Then, write in a number according to how well the statement describes you (see below). After that, add up all the numbers you wrote down within each subsection (i.e. questions 1- 7 are the linguist subsection, etc.) and total them in the space provided. Compare your results from each subsection against the others and feel free to share them with your peers!

1 = Statement does not describe you at all; 2 = Statement describes you very little; 3 = Statement describes you somewhat; 4 = Statement describes you pretty well; 5 = Statement describes you exactly

I pride myself on having a large vocabulary. _____
I enjoy learning new words and do so easily. _____
I love to read and do so daily. _____
I enjoy hearing challenging lectures. _____
I like to keep a daily journal of my daily experiences. _____
I read and enjoy poetry and occasionally write my own. _____
I talk a lot and enjoy telling stories. _____

Linguist Subsection Total: ☐

Using numbers and numerical symbols is easy for me. _____
I often develop equations to describe relationships and/or to explain my observations. _____
I often see mathematical ratios in the world around me. _____
Math has always been one of my favorite classes. _____
I like to think about numerical issues and examine statistics. _____
I seem to understand things around me through a mathematical sense. _____
I enjoy doing puzzles. _____

Math/Logical Subsection Total: ☐

Music is very important to me in daily life. _____
I have wide and varied musical interests including both classical and contemporary. _____
I have a very good sense of pitch, tempo, and rhythm. _____
My music education began when I was younger and still continues today. _____
I am good at playing an instrument and singing. _____
I can remember the tune of a song when asked. _____
I take pride in my musical accomplishments. _____

Musical Subsection Total: ☐

I always know where I am in relation to my home. _____
I do not get lost easily and can orient myself with either maps or landmarks _____
Knowing directions is easy for me. _____
I have the ability to represent what I see by drawing or painting. _____
My ability to draw is recognized and complimented by others. _____
I can easily duplicate color, form, shading, and texture in my work. _____
Seeing things in three dimensions is easy for me, and I like to make things in three dimensions. _____

Spatial Subsection Total: ☐

I consider myself an athlete. _____
I feel really good about being physically fit. _____

I have good balance and eye-hand coordination and enjoy sports which use a ball. _____
My outstanding coordination and balance let me excel in high-speed activities. _____
I like being outdoors, enjoy the change in seasons, and look forward to different physical activities each season. _____
I like the excitement of personal and team competition. _____
I like to move around a lot. _____

Kinesthetic Subsection Total: ☐

I feel like people of all ages like me. _____
I like to be with all different types of people. _____
I respond to all people enthusiastically, free of bias or prejudice. _____
I enjoy new or unique social situations. _____
I enjoy complimenting others when they have done well. _____
I am quick to sense in others dishonesty and desire to control me. _____
I feel safe when I am with strangers. _____

Interpersonal Subsection Total: ☐

I often look for weaknesses in myself that I see in others. _____
I often think about the influence I have on others. _____
I believe that I am responsible for my actions and who I am. _____
I try not to waste my time on trivial pursuits. _____
I often think about the problems in my community, state, and/or world and what I can do to help rectify any of them. _____
I am always totally honest with myself. _____
I enjoy being alone and thinking about my life and myself. _____

Intrapersonal Subsection Total: ☐

The world of plants and animals is important to me. _____
I enjoy my pets. _____
I like learning about nature. _____
I enjoy caring for my house plants. _____
I enjoy hunting and fishing. _____
I enjoy hiking in natural places. _____
I look forward to visiting the zoo. _____

Naturalist Subsection Total: ☐

Results: The subsection with the greatest total describes which of Gardner's Multiple Intelligences would apply best to you, while the other intelligences could be stimulated through variety in instruction methods.

Courtesy: Shelton, L. , Conan, J. S. , & Fulghum-Nutters, H. Assessment: find your strengths!. Retrieved February 1, 2009, from Literacyworks presents: Multiple intelligences for adult literacy and education Web site: http://literacyworks.org/mi/assessment/findyourstrengths.html