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Inquiry Teaching in the College Classroom

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Abstract

Discussions among professors often center on the topic of how to get students involved, how to enable them, and motivate them to learn more and to learn it better. The standard lecture format leaves most of us-teachers and students alike-wanting more. What can we do to accomplish these goals? A teaching method known as "inquiry teaching" has been adapted to the college classroom where followers claim the method builds analytic skills, improves students' knowledge base, and promotes student engagement. Inquiry students are more likely to build hypotheses, integrate, and apply new knowledge more than students in traditional lecture-format classrooms. Although inquiry-based learning may be beneficial, in a study of 77 faculty members at two universities, students' grades in inquiry-based classes were not significantly higher than grades in standard lecture classes. Inquiry methods are not a panacea for college student learning.

Keywords: Inquiry teaching, teaching method, student grades.

How often do we leave the classroom feeling as if our students did not get the main points, did not understand the concepts, or perhaps, that they had not even read the required material? How often does it seem that they just do not care? How often do we take action to remedy this state of affairs? Do we resort to the same old lecture format? Do we ask the same tired essay questions? Tell me all you know about so and so. Is there a better way?

Most teaching styles follow the traditional lecture format-we talk-they listen. They probably take notes. Students are conditioned to be passive learners; but what if we changed our methods to one that would inspire them to know more and to teach themselves? Would they learn more and enjoy the experience?

In most American universities, the lecture-discussion format is traditional. Some students may participate with comments or questions but generally want to know what will be on the test and what they should study. The traditional method may facilitate subject matter knowledge but it does nothing for enhancing the creative habits of mind that are the hallmark of higher learning. Regurgitation of facts and lecture notes enhances memorization skills but does little for one's analytical ability.

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Inquiry teaching methods break from the traditional lecture format and ask the student to take an active role in his or her own learning. Inquiry learning begins when students are presented with a problem and some suggestions and tools for finding the answer to that problem. They struggle, with help from the instructor, through the problem until they reach their answer, having constructed it themselves. Beyer (1979) in his book on the inquiry method states,

> "Inquiry teaching involves creating, conducting and evaluating learning experiences that require students to go through the same processes and develop or employ the same knowledge and attitudes they would use if engaged in independent rational inquiry. (84)."

People learn by making connections from principle to practice and by collecting pertinent facts in a logically-ordered way. Inquiry requires the identification of facts and assumptions, the use of critical thinking, consideration of a range of alternatives, and stimulates the mental processes toward synthesis of information, application of principle, and evaluation of what has been done (French, 2005; Vega and Tayler, 2005). Students become more engaged in their learning by taking an active role.

In fact, theories of student engagement are at the heart of inquiry-based learning. Miley (2009) demonstrated that interested, focused students are more engaged students and numerous studies show that the right kind of inquiry facilitation with ample feedback goes far toward motivating students to be engaged in their own learning (Gose, 2009; Hsu, Kysh, Ramage, Resek, 2009; Greene, Marti & McClenney, 2008; Spronken-Smith, Bullard, Ray, Roberts, & Keifer, 2008). Why are these highly integrative tasks so beneficial? Students must devote substantial time and effort to solve inquiry-based problems, such as why does ice melt or why do people vote the way they do? Activity centers on what *they* know, what information *they* can find and how *they* can best organize the information so that it has meaning for *them*. Engagement theory posits that students who make a greater effort invest in themselves and perform better. The National Survey of Student Engagement, (NSSE) supports the finding that doing rather than thinking promotes more positive outcomes (Gordon, Ludlum, and Hoey, 2008).

In a science classroom the method begins with the description of a problem, such as why do objects fall? Or, in a social science classroom, students may be presented with a broad question such as what makes groups of people move across the globe over time? Students are placed in a group where discussion of the problem may begin. The teacher facilitates the discussion by providing a few foundational facts, or tells the students where to find them. In more advanced forms of inquiry, the teacher would be relatively silent, letting the students' natural curiosity and previous class work guide the students' efforts. Students are asked to come up with a hypothesis that would, if tested, provide answers to the question or problem posed and then to think of ways to test that hypothesis (Adamson, et.al., 2000; Ensrud, 1997). Building a hypothesis, testing, synthesizing, evaluating, and applying new information are part and parcel of inquiry-learning and they form Bloom's taxonomy of higher-order skills.

As facilitator, the teacher would help them plan and carry out their investigation. Teachers can witness and note how students learn and can deal with any problems as they arise (Bender, 2005; French, 2005; Wyatt, 2005; Gearhart & Saxe, 2004). Or, a teacher may define the question, the processes of answering that question, and the means by which to interpret the findings, in more structured approaches (Colburn, 2004). Students learn from each other as well as from the teacher as students devise ways to test the hypothesis and carry out the actual experiments (Burns, 2005, Robbins, 2005). With data they have gathered, students form a conclusion about their hypothesis. Is it correct or should it be tossed out? Is more information needed? How will that information be gathered? These questions and others like them allow the student to solidify in his or her mind what has been learned without being “told” it is so. Inquiry methods keep learners actively engaged (Huba & Freed 2000, Wyatt, 2005), support collaborative learning and social skills, and enlist more cooperation among students than would be achieved by a lecture (Kuh, 2008; Spronken-Smith, et al., 2008; Robbins, 2005; Vega & Tayler, 2005; Huba & Freed, 2000). The teacher helps students understand any assumptions that may surface (French, 2005).

American secondary school teachers adapted the inquiry method for use in their science classrooms in the 1960s as a counter to recent Soviet advances (Education Commission of the States, 1996, 1995). Today, the National Science Education Standards promote its use in science curricula throughout elementary and secondary schools (National Research Council, 2000; Crawford, 1997). A small percentage, if this sample is representative, of college teachers use it as well. The literature recounts numerous ways inquiry teaching has benefited the K-12 student. The question becomes, for university professors, can inquiry methods be made useful for the college course and does this method produce smarter students as represented by grades?

Qualitative and descriptive studies on the merits and problems of inquiry-based learning abound but scholars note the paucity of statistical data on inquiry teaching and its results, especially at the college level (Gose, 2009; Spronken-Smith, et. al., 2008; Hsu et al., 2009; Flick, 1997). Harada and Yoshina claim that the inquiry approach is more flexible than the traditional approach and promotes the *use* of technology as a tool, rather than learning *about* technology (2004). Inquiry-based teaching methods can also promote team-building skills (Haight, Kelly, & Bogda, 2005; Memory, Yoder, Bolinger, & Warren, 2004; Bingman, 1970). Students learn to link facts, explore their own capabilities, i.e., to “connect the dots” (Silverbank, 2001).

Hsu et al. (2009) found a lower math failure rate in inquiry classrooms as opposed to traditional math classes and Kommarraju and Karau (2008) noted that inquiry-based activities held a widely-changeable value as placed on them by diverse groups of students (Berg, Bergdahl, & Lundberg 2003). Damnjanovic found that pre-service middle grades science teachers have a more favorable view of inquiry methods than do in-service teachers at that level (1999). Two other, small college studies showed that in an inquiry-based seminar style class, there were more participating students, longer discussions, and more student-to-student interaction than in traditional lecture courses (Philips & Powers, 1979). They report the rates of interaction but do not statistically investigate the relationships between the variables. At another college, a faculty survey reported that students taught using inquiry methods had better retention, showed more initiative, received fewer Fs, engaged in more group activities, and focused on the process of investigation, rather than on the grade. Thirty university and secondary faculty (14 college level faculty and 16 secondary school teachers), reported that in inquiry-based classes students were more creative, participated more often, had greater retention, and failed fewer courses (Vega & Tayler, 2005). On test outcomes, however, there was a less significant difference although no specific data were reported.

While inquiry teaching and learning has its followers, it also has its detractors. Inquiry is also criticized for being difficult to use with students who do not possess good analytical ability (Baker, Lang, & Lawson, 2002), for failing to reach lazy students (Orton-Johnson 2009), and for being too labor-intensive (Hsu et al., 2009). In situations where teachers have to meet schedules or "teach to the test" inquiry methods may pose logistical problems. Start small. Gose (2009) and Flick (1997) found that most, if not all, students can learn through inquiry, but may need a little extra help from the teacher/facilitator. The method clearly demands more from student--and teachers--who will likely possess differing skill, knowledge, and motivation levels (Zachry, 1985).

However, if inquiry-based teaching engages students and the range of inquiry activities promotes better learning then one should see better outcomes in inquiry-based classes compared to standard, traditional lecture-based classes. Students should perform better on assignments and exams, and should write better papers. Final grades might be higher as well.

Methodology

Seventy-seven faculty members at two universities (12.8 percent) in Georgia responded to an anonymous 14-question electronic survey (Appendix A) to gauge faculty usage and perception of the value of inquiry methods and to provide mean outcomes for an inquiry-based class and for a standard lecture-based class. The survey asked teachers which of a variety of inquiry-based methods they used and how often they used them. Faculty chose from 5 possible answers relating to their or their students' use of the technique: "Always," "Most of the Time," Sometimes," "Seldom," and "Never." Although this is still subjective, it was thought to be a clearer descriptor than a strict numerical ranking. For quantitative analysis purposes a numerical value was assigned to each rank. Four points was assigned to "Always," 3 to "Most of the Time," and so forth, through 0 points for "Never." Demographic questions included age range, number of years teaching, and whether respondents earned their degree from an American university. Regarding outcomes, instructors were asked for a class mean for an exam, a paper, an assignment, and the final grade in percentage terms for an inquiry class and a standard class. Faculty could answer: "90-100%," "80-89.9%," "70-79.9%," and "60-69.9%, or "<60%." Teachers were asked to rate their attendance in the two classes as "higher than normal," "normal," or "lower than normal" and were allowed to define what is "normal." Normal attendance was coded as a "1" value, lower attendance a "0," and higher than normal, a "2" value.

A summary of descriptive statistics is shown here in Tables 1A, 1B, and 1C. *T*-Tests were performed to determine significant differences between inquiry-based outcomes and standard-format outcomes. *T*-values were also recorded in Table 1A.

A correlation matrix was created in order to investigate relationships between these variables and to provide further direction, Table 2.

From correlations, deeper relationships can be hypothesized. Five regression models were constructed to assess the effect of inquiry methods on students' outcomes. If inquiry techniques do at the college level what they do at the elementary and secondary levels then one would expect to see substantial positive relationships between inquiry-based activities and outcomes as represented by grades. The basic regression model is hypothesized where "$X_{1....n}$" represents a range of 16 independent inquiry-related variables with correlations over .500, and "$Y_{1...5}$" represents an exam grade, an assignment grade, a paper grade, the final grade, and finally, attendance.

Each full regression model takes the basic form, $a + b_{X1....n} = Y_{1...5}$, where the totality of inquiry variables should positively affect each dependent outcome variable. The ability to build hypotheses, make inferences, transfer new knowledge and like activities would all combine to contribute to students' improved higher-order skills, and, in turn, their grades on these measures.

Limitations

Although self-reporting is often questioned for its validity, it was the most practical way to assess current methods and student responses. It would not have been logistically possible to visit dozens of classes over time to observe each student's development although such a controlled-experiment would have been ideal. A perfect design should control for environmental factors, personality issues, and potential problems like time allotted for problem solving, instructor feedback, etc. … And then, of course, there is the problem of the occasional student's unwillingness to do the work or more temporal issues such as merely "having a bad day" that obfuscate any attempts to discover true relationships.

The sample size is rather small at 77 and we do not know how teachers calculated their means, or even if they truly used inquiry methods. We make a leap of faith when we say that students in inquiry classes do what they are supposed to do every single time and that their performance reflects that involvement. We all have students who show up but are mentally elsewhere.

Findings and Discussion

Mean results for inquiry methods used fall, almost exclusively between "Sometimes" (2.00) and "Most of the Time" (3.00). The standard deviations are large, here, and indicate a wide range of student abilities. Students respond to open-ended questions, problems, conduct demonstrations, and even sometimes build hypotheses and make

Table 1A. Inquiry Method Results.

Question	Inquiry Methods	Mean Response	Std. Dev.
1.	How often do students in your course respond to: a. Open ended questions	2.953	.862
	b. Scenarios	2.486	.851
	c. Problems	2.645	.974
	d. Demonstrations	2.280	1.257
2.	How often do students provide input in form of: a. Previous experiences?	2.346	1.100
	b. Prior knowledge	2.551	.893
	c. Hypotheses	2.187	1.191
	d. Inferences	2.085	1.147
3.	How often do students gain info on concepts in relation to Q 1 & 2 from: a. Other students?	2.682	1.060
	b. From You?	2.860	1.023
	c. Other resources?	2.505	1.013
4.	How often do students construct their own conceptual understanding from integrating knowledge?	2.224	1.176
5.	How often do students apply this newly constructed knowledge to new problems?	2.336	1.181
6.	How often do students a. Reflect on newly constructed knowledge?	2.215	1.174
	b. Evaluate their newly constructed knowledge?	2.065	1.223
	c. Modify their newly constructed knowledge?	2.135	1.098
7.	How often is students' curiosity inspired a. With problems from life or career?	2.542	.954
	b. With questions from hypothetical situations?	2.542	.883
8.	How often do students put their curiosity into action by a. Researching?	1.990	1.131
	b. Experimenting?	1.579	.952
9.	How often do you accept and build on students' conclusions from these activities?	2.271	1.112
10.	How often do you give students time to a. Compare notes with each other?	2.178	1.071
	b. Discuss their conclusions among themselves?	2.234	1.210
	c. Share their experiences?	2.589	1.124
11.	How often do students transfer new knowledge to new situations?	2.439	1.083
12.	How often do you foster students' reexamination of initial questions and problems posed?	2.411	.911
	"Always" = 4 "Most of the Time" = 3 "Sometimes" = 2 "Seldom" = 1 "Never" = 0		

Table 1B Outcome Means & Significance.

	Connecting Outcomes to Methods			**Mean Differences**	
13	**Inquiry-Based Class (es)**	**Mean**	**St Dev**	***t*-value**	**Sig.**
a	The average grade on an exam was (compared to standard class)	2.623	.932	.634	.528
b	The average grade on an assignment was (compared to standard class	2.935	.469	.208	.605
c	The average grade on a paper was (compared to standard class)	2.553	.839	.546	.586
d	The average final grade was (compared to standard class)	2.610	.814	1.808	.074
e	Attendance was (check appropriate box) ("1" = "Normal"; "0" = Lower than Normal; "2"= Higher than Normal) (compared to standard class)	1.014	.677	2.236	.028
14.	**"Standard" teaching class** (Lecture-note taking)				
a	The average grade on an exam was (compared to inquiry class)	2.532	.680	.634	.528
B	The average grade on an assignment was (compared to inquiry class)	2.727	.821	.208	.605
C	The average grade on a paper was (compared to inquiry class)	2.487	.902	.546	.586
D	The average final grade was (compared to inquiry class)	2.377	.859	1.808	.074
E	Attendance was (check appropriate box) ("1" = "Normal"; "0" = Lower than Normal; "2"= Higher than Normal) (compared to inquiry class)	.805	.608	2.236	**.028**

inferences. Students gain significant knowledge from other students, from their instructor, and from other resources. Students are likely to be able to construct their own knowledge and apply that knowledge to new problems and, perhaps reflect on what they have done and possibly evaluate it if asked to do so. Often, their curiosity is inspired by life or career problems and by hypothetical situations. Faculty who use inquiry methods generally accepts students' conclusions and give them time to advance these ideas by sharing and transferring information to new situations. Instructors promote student reexamination of the original question or problem as students proceed.

Most faculty who responded to the survey are over 50, and 43 percent have taught for 11-20 years. Six to ten years is the average time teachers have spent in higher education. Apparently many teachers either left the public school system to advance their careers or left higher education to return to the elementary and secondary school systems. Thirty-one percent say they have used inquiry methods for between 11-20 years and a slight

Table 1C. Demographics.

DEMOGRAPHICS		Percentages	
13.	How many years have you taught in higher education?	1 - 5yrs - **16%** 11-20yrs - **33%**	6-10yrs **- 35%** >20yrs – **16%**
14.	How many years have you been teaching at any level?	1 - 5yrs – **14%** 11-20yrs – **43%**	6-10yrs – **21.5%** >20yrs – **21.5%**
15.	How many years have you used inquiry teaching methods?	1 - 5yrs – **28%** 11 -20yrs - **31%**	6-10yrs – **30%** >20yrs – **11%**
16.	Did you receive your degree from an American College/University?	Yes - **95%**	No - **5%**
17.	Did you receive formal instruction in teaching as a graduate student?	Yes - **48%**	No – **52%**
18.	My age range is	< 30yrs – **14%** 41-50yrs–**20%**	31-40yrs – **23%** > 50yrs – **44%**

majority (52% to 48%) say they did not receive any instruction on teaching as a graduate student. Ninety-five percent received their degree from an American university.

The mean differences for outcomes in inquiry-based classes and standard lecture-based classes were insignificant in all but one area-attendance (p = .02). The average grades for an inquiry class exam, assignment, paper, and the final grade were slightly higher than grades in the standard class but as the difference is insignificant, not much can be made of these differences.

This data produced a large variable set with over 1,500 correlations. Many were significant and strong but most of the associations were weak—below .500. A smaller matrix, Table 2, is constructed to highlight the strongest correlations, i.e., the most salient variables in the variable set.

From the statistics in Table 2, as might be expected, one can see that prior knowledge, previous experiences, reflecting on, and sharing those experiences figure strongly in students' abilities to handle open-ended questions, make demonstrations, and modify and evaluate information. The mental skill of making an inference may lead a student to build a hypothesis and it is clear that students who share knowledge are more likely to modify that knowledge or transfer new knowledge to new situations as these variables are related. Those who can evaluate information are also more likely to modify their knowledge, another critical step in learning. Those who can transfer new knowledge are also likely to reexamine what they originally thought they knew. Inquiry method variable correlations were not so high as to suspect that they co-vary.

Correlations between the demographic variables in the study and the desirable end-state outcomes were weak. The relationship between the number of years of inquiry teaching and students' ability to transfer knowledge (.469), and for student demonstrations (.320),

Table 2 Correlation Matrix.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
		Oeq	**Sce**	**Pro**	**Dem**	**PE**	**H**	**Inf**	**OS**	**IK**	**AK**	**R**	**E**	**M**	**Ins**	**C**	**Tra**	**Ex**	**As**	**Pa**	**FG**	**Att**
1	OpenEndQ	1																				
2	Scenario	.54	1																			
3	Problem	.36	.31	1																		
4	Demonstrat	.37	.49	.54	1																	
5	PreExper	.55	.38	.49	.43	1																
6	Hypotheses	.31	.47	.06	.41	.28	1															
7	Inferences	.32	.44	.24	.57	.53	.70	1														
8	Other Stud	.39	.26	.40	.51	.50	.27	.49	1													
9	Integ Know	.37	.11	.19	.18	.32	.29	.35	.72	1												
10	ApplyKnow	.33	.33	.34	.38	.47	.31	.48	.69	.74	1											
11	Reflect	.42	.24	.30	.35	.36	.30	.44	.68	.72	.65	1										
12	Evaluate	.40	.08	.20	.26	.26	.27	.32	.45	.69	.47	.71	1									
13	Modify	.29	.23	.20	.41	.36	.19	.50	.63	.55	.61	.73	.64	1								
14	Inspire	.19	.34	-.02	.31	.07	.56	.33	.25	.13	.04	.21	.20	.18	1							
15	Curios?	.27	.21	.34	.57	.30	.35	.36	.45	.33	.32	.49	.57	.45	.51	1						
16	Transfer	.24	.30	.26	.48	40	.39	.41	.40	.32	.37	.48	.41	.52	.56	.52	1					
17	Exam	.02	.01	.05	.06	.10	.19	.20	.25	.21	.11	.19	.52	.16	.28	.24	.22	1				
18	Assignment	-.15	-.23	-.23	-.23	-.20	-.15	-.13	.03	-20	-.20	-.06	.18	-.06	-.20	-.11	-.22	.12	1			
19	Paper	.08	-.03	.02	.17	-.12	.04	.06	-.23	.01	-.12	.13	-.03	.12	.18	.27	,23	.38	.17	1		
20	Final Grade	-.05	-.03	.00	.11	-.05	.05	.11	.03	.05	-08	.20	.19	.06	.16	.17	.18	.54	-.10	.58	1	
21	Attendance	.02	-.02	.01	-.13	-.07	.00	-.23	-.02	-.11	-.15	-.06	.15	-.14	.11	.01	-.20	.11	.35	.30	-.05	1
		Oeq	**Sce**	**Pro**	**Dem**	**PE**	**H**	**Inf**	**OS**	**IK**	**AK**	**R**	**E**	**M**	**Ins**	**C**	**Tra**	**Ex**	**As**	**Pa**	**FG**	**Att**

might have been higher. The correlation between the number of years using inquiry methods and a grade on a paper was a puny .367. The relationships between inquiry methods and inquiry outcomes were also surprisingly weak. Only one, the relationship between evaluating information and the inquiry-exam grade was over .50, at .52. All other correlations between demographic variables and inquiry outcomes lay between .00 and .290.

None of the full regression models of 16 independent inquiry variables positively impacted inquiry outcomes. The full model *R*-squared value for each model was low and the adjusted R-squared value even lower, and insignificant. Given these results our original hypothesis that inquiry methods would impact outcomes is rejected. Apparently inquiry methods have no effect on students' grades on exams, assignments, papers, or on the final grade, but only a negligible effect on attendance.

Discussion & Conclusion

Research is important for what it tells us even when that is unexpected. Faculty perceptions indicate that students do gain from inquiry learning but the only relationships that have any meaning here are those between the inquiry variables themselves as might be expected. A majority of faculty said they received no instruction on how to teach and many have come from the public school system.

While some instructors may feel that any improvement in grades offsets the extra effort involved, others can probably keep the lecture-note format and see similar outcomes. Will the students in the standard classes enjoy the class as much as they would have if they had been in an inquiry class? Will they be as "engaged"--probably not. Engagement, as represented here by constructing one's own knowledge through a series of self-

Table 3A. Inquiry Exam Grade.

No.	Independent Variables Student activities	Full Model *R* Squared Adjusted *R* Squared	*F*-Value/ *p* value	Variable Coefficients	*t*- value	*p* value
1	Response to: Open-ended questions	.223 .000	.988 .482	-.040	3.508	.001
2	Scenarios			-.216	-1.072	.288
3	Problems			.069	.426	.671
4	Demonstrations			-.125	-.750	.456
5	Previous experiences			.115	.698	.488
6	Build hypotheses			-.022	-.112	.916
7	Making inferences			.129	.689	.493
8	Gain info from other students			-.199	-.876	.384
9	Integrating knowledge			-.337	-1.342	.185
10	Applying new knowledge			.313	1.661	.102
11	Students' reflections on newly constructed knowledge			.237	1.275	.207
12	Evaluate new knowledge			.089	.432	.667
13	Modify new knowledge			-.046	-.228	.820
14	Students Inspired by hypothetical situations			.430	1.954	.055
15	Students curious about research			.013	.067	.946
16	Transfer new knowledge			-.111	-.588	.558

directed exercises may help students feel involved but there is no evidence here to assert grade improvement.

Looking deeper at the data is a key to what happened. The inquiry method means in Table 1A show that instructors use these methods between "some of the time," and "most of the time." Inquiry methods are not used "always." This lapse may signal a break in continuity of method sufficient to allow students' minds to wander away from their self-directed course. The limitations of the study loom large. We do not know how the instructors used the methods. Is it necessary for inquiry to be the sole method, consistently throughout the semester? Until one manages a controlled experiment over time in several inquiry and standard classes, the question will remain unanswered. Faculty should sample various inquiry techniques and observe the results. They are the best judges of whether students are learning. Analytic thought processes do improve with inquiry but, for now, do not bet the farm on the inquiry method as a panacea for student improvement.

Table 3B. Inquiry Assignment Grade.

No.	Independent Variables Student activities	Full Model *R* Squared Adjusted *R* Squared	*F*-Value/ *p* value	Variable Coefficients	*t*- value	*p* value
1	Response to: Open-ended questions	.190 .000	.809 .670	.164	.210	.834
2	Scenarios			-.494	-.633	.529
3	Problems			-.537	-.853	.397
4	Demonstrations			-.429	-.655	.508
5	Previous experiences			-.171	-.266	.791
6	Build hypotheses			.230	.298	.766
7	Making inferences			.242	.332	.741
8	Gain info from other students			-.224	-.254	.800
9	Integrating knowledge			-.950	-.976	.333
10	Applying new knowledge			-.130	-.178	.859
11	Students' reflections on newly constructed knowledge			.775	1.078	.285
12	Evaluate new knowledge			.086	.109	.913
13	Modify new knowledge			.284	.365	.716
14	Students Inspired by hypothetical situations			-.796	-.932	.353
15	Students curious about research			.407	.557	.579
16	Transfer new knowledge			-.478	-.655	.515

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Table 3C Inquiry Paper Grade.

No.	Independent Variables Student activities	Full Model *R* Squared Adjusted *R* Squared	*F*-Value/ *p* value	Variable Coefficients	*t*- value	*p* value
1	Response to: Open-ended questions	.147 .000	.580 .885	.056	.286	.776
2	Scenarios			-.104	-.543	.589
3	Problems			-.193	-1.251	.216
4	Demonstrations			.095	.602	.550
5	Previous experiences			.152	.915	.364
6	Build hypotheses			-.068	-.358	.721
7	Making inferences			.018	.099	.921
8	Gain info from other students			.097	.447	.656
9	Integrating knowledge			-.118	-.494	.623
10	Applying new knowledge			-.173	-.964	.339
11	Students' reflections on newly constructed knowledge			.164	.926	.358
12	Evaluate new knowledge			.097	.498	.620
13	Modify new knowledge			-.154	-.801	.426
14	Students Inspired by hypothetical situations			.016	.074	.941
15	Students curious about research			.068	.380	.705
16	Transfer new knowledge			.070	.378	.707

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Table 3 D Inquiry Final Grade.

No.	Independent Variables Student activities	Full Model *R* Squared / Adjusted *R* Squared	*F*-Value/ *p* value	Variable Coefficients	*t*- value	*p* value
1	Response to: Open-ended questions	.205 / .000	.885 / .589	-.158	-.876	.384
2	Scenarios			-.045	-.247	.805
3	Problems			-.079	-.546	.587
4	Demonstrations			.136	.912	.366
5	Previous experiences			.008	.052	.958
6	Build hypotheses			-.196	-1.102	.275
7	Making inferences			.206	1.224	.226
8	Gain info from other students			-.161	-.791	.432
9	Integrating knowledge			-.027	-.121	.904
10	Applying new knowledge			-.109	-.648	.519
11	Students’ reflections on newly constructed knowledge			.442	2.667	.010
12	Evaluate new knowledge			.070	.384	.703
13	Modify new knowledge			-.283	-1.583	.119
14	Students Inspired by hypothetical situations			.168	.854	.397
15	Students curious about research			-.058	-.342	.733
16	Transfer new knowledge			.025	.147	.883

Table 3E Inquiry Attendance.

No.	Independent Variables Student activities	Full Model *R* Squared Adjusted *R* Squared	*F*-Value/ *p* value	Variable Coefficients	*t*- value	*p* value
1	Response to: Open-ended questions	.247 .010	1.044 .429	-.066	-.436	.664
2	Scenarios			.017	.114	.909
3	Problems			.093	.774	.442
4	Demonstrations			-.043	-.343	.733
5	Previous experiences			.143	1.124	.266
6	Build hypotheses			.195	1.343	.185
7	Making inferences			-.333	-2.349	.022
8	Gain info from other students			.085	.490	.626
9	Integrating knowledge			-.049	-.263	.793
10	Applying new knowledge			-.068	-.486	.628
11	Students' reflections on newly constructed knowledge			.047	.345	.731
12	Evaluate new knowledge			.045	.297	.767
13	Modify new knowledge			.080	.522	.606
14	Students Inspired by hypothetical situations			.261	1.522	.603
15	Students curious about research			-.004	-.031	.975
16	Transfer new knowledge			-.338	-2.387	.020

Appendix A. Inquiry Teaching Survey

Inquiry Teaching Survey

This survey is anonymous. Please do not place your name or identifying marks on this survey. If you would like a copy of the results, please so indicate in your return email. Thank you for your participation.
Please mark your answer with an "x"
Key: **Always**, Occurs nearly every class meeting
Most of the time, Occurs nearly every class meeting in any course
Sometimes, Occurs in about half of class meetings in any course
Seldom, Occurs at least once per semester in any course
Never, Occurs less than once per semester

Question		Always	Most of Time	Sometimes	Seldom	Never
1.	How often do students in your course respond to:					
	a. open-ended questions					
	b. scenarios					
	c. problems					
	d. demonstrations					
2.	Considering your response to number 1, how often do students provide input in the form of					
	a. previous experiences					
	b. prior knowledge					
	c. hypotheses					
	d. inferences					
3.	How often do students in your course gain additional information on concepts and ideas in relation to #1 and #2 from:					
	a. other students					
	b. from you					

Question		Always	Most of Time	Sometimes	Seldom	Never
4.	How often do students actively construct their own understanding from integrating knowledge from many sources?					
5.	How often do students apply newly constructed knowledge to new problems or scenarios?					
6.	How often do students					
	a. reflect on newly constructed knowledge?					
	b. evaluate their newly constructed knowledge?					
	c. modify their newly constructed knowledge?					
7.	How often is students' curiosity inspired					
	a. with problems from life or career?					
	b. with questions from hypothetical situations?					
8.	How often do students put their curiosity into action by					
	a. researching?					
	b. experimenting?					
9.	How often do you accept and build on students' conclusions from these activities?					
10.	How often do you give students time to					
	a. compare notes with each other?					
	b. discuss their conclusions among themselves?					
	c. share their experiences?					
11.	How often do you give students time to transfer new knowledge to new situations?					
12.	How often do you foster students' reexamination of initial questions and problems posed?					

	Connecting Grades and Outcomes to Inquiry Methods.					
13	**Inquiry-Based Class (es)**	**90-100%**	**80-89.9%**	**70-79.9%**	**60-69.9%**	**< 60%**
a	The average grade on an exam was					
b	The average grade on an assignment was					
c	The average grade on a paper was					
d	The average final grade was					
		Higher than Normal	Normal	Lower than Normal		
e	Attendance was (check appropriate box)					
14	**"Standard" teaching class** (Lecture-note taking)	**90-100%**	**80-89.9%**	**70-79.9%**	**60-69.9%**	**< 60%**
a	The average grade on an exam was					
b	The average grade on an assignment was					
c	The average grade on a paper was					
d	The average final grade was					
		Higher than Normal	Normal	Lower than Normal		
e	Attendance was (check appropriate box)					