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# Using Humanistic Content and Teaching Methods to Motivate Students and Counteract Negative Perceptions of Mathematics

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*It is nothing short of a miracle that modern methods of instruction have not yet entirely strangled the holy curiosity of inquiry.* - Albert Einstein [5, p. 31]

# Using Humanistic Content and Teaching Methods to Motivate Students and Counteract Negative Perceptions of Mathematics

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Many people agree that mathematics education today is failing a large number of students, but there is vast disagreement about how to solve the problem. Many voices are calling for states to adopt a standards-based curriculum and for mathematics educators at all levels to reform, broaden and enliven the curriculum so students will see mathematics as more interesting and useful. Some want schools to spend more time on mathematics and do more high-stakes testing. Other voices blame the reform movement for poor student performance and claim the solution is to return to the "Old Math" and emphasize drill and practice, memorizing procedures, computational accuracy, basic skills, etc.

In this paper I will examine several questions:

- How is math commonly taught, why is it taught this way, and what are the outcomes?
- Who are some of the voices calling for change and what are they saying?
- Can a humanistic approach produce positive results in students who have learned to dislike math and have not been successful in a traditional classroom?

In many mathematics classrooms, traditional teaching methods are still the dominant form of instruction. Teachers demonstrate a procedure, show a few examples, and assign students 30 similar exercises for drill and practice. Students often gain little real understanding of what they are doing or why they are doing it, so they learn to survive by memorizing procedures and trying to match them to similar problems when taking exams. Because they are shown only the end product – the theorems and algorithms – they never learn to think mathematically, to share in the joy of discovery, or to understand and appreciate of the great ideas in mathematics. The end result is that many students come to view mathematics as boring, useless in real life, and increasingly incomprehensible. As Lynn Steen writes, “Few can doubt that the tradition of decontextualized mathematics instruction has failed many students… who leave high school with neither the numeracy skills nor quantitative confidence required in contemporary society” [19, p. 5].

There are several reasons why mathematics continues to be taught in the traditional manner. One prominent reason is that a sizable fraction of teachers, especially at the elementary level, don’t understand (or like!) mathematics themselves. This was borne out in a recent study by Liping Ma, a Carnegie Foundation researcher. “Dr. Ma’s most shocking conclusion is that most American schools don’t teach mathematical foundations of arithmetic because teachers themselves weren’t taught those principles. Pupils are shown only what teachers know: to do operations by rote, using tricks (like borrowing sugar) to help remember rules” [16]. Teachers with little interest in mathematics are not likely to adopt new methods which could expose their own inadequate understanding of mathematics.

A second reason is that many mathematics teachers view their subject as a hierarchy which leads to calculus and beyond, so their curriculum includes only those topics which prepare students for this goal. As Dr. David Bressoud, chair of the Mathematics Department at Macalester College, writes, “Too many mathematicians in academia have long had the attitude that their purpose was to train people to get PhDs in mathematics and anything that happened beyond that was peripheral" [17]. Johnny W. Lott, president of the National Council of Teachers of Mathematics (NCTM), agrees that, in high school, "the curriculum has been developed in a way that would lead students toward a calculus class" [10]. Edward Burger and Michael Starbird commented on the results of this viewpoint in the December, 2000, issue of *Focus*. "Students often absorb this idea: they see mathematics as an unending string of courses that starts with arithmetic and progresses relentlessly through high school algebra, geometry, pre-calculus, calculus, and so on ad infinitum or perhaps ad nauseam. Each subsequent course is viewed as dependent on the previous one, and there is no independent payoff from any particular course. Having students struggle up the first two rungs of a ladder they will never climb is a curricular strategy born of habit rather than thought" [1, p. 10].

A third reason mathematics continues to be taught in the traditional way is efficiency. I have heard many teachers say, "I would like to include more meaningful applications and help students discover some math concepts on their own but it takes too much time. I have to cover the material so they'll be ready for the next course." Motivation and understanding are sacrificed in order to transmit the maximum amount of facts. I believe a fourth reason is the background of the mathematics teachers themselves. For the most part they were taught in the traditional way and were successful at it, so they have a hard time understanding why everyone else cannot learn and enjoy mathematics just like they did. They often place the blame for low mathematics achievement on students, parents or society rather than admit that their curriculum or teaching methods are failing to produce good results for many of their students. Hester Lewellen goes even further stating "There is sometimes a kind of arrogance in the people that CAN do mathematics. It is fed by the culture. It's unspoken, but kids see it. Those who succeed at mathematics are part of an inner circle and everybody else is an outsider" [9].

There are also a significant number of mathematics educators in the United States who are trying to implement reforms such as those recommended by the National Council of Teachers of Mathematics. Proper use of these standards by well trained teachers has produced good results, but a study by the United States Department of Education found that many teachers did not really understand the goals of the reform or know how to achieve them. For example, when asked about the key goals of the reform movement, "over 80% of the teachers in the study referred to something other than a focus on thinking which is the central message of the mathematics reform movement. The majority of the teachers cited examples of hands-on math or cooperative learning, which are techniques included among the reform recommendations. However, these techniques can be used either with or without engaging students in real mathematical thinking. **These findings suggest that the instructional habits and attitudes of U.S. mathematics teachers are only beginning to change in the direction of implementation of mathematics reform recommendations. Teachers' implementation of the reform still concentrates on isolated techniques rather than the central message, which is to focus on high-level mathematical thought**" (bold in original) [20, p. 47].

The outcomes of our present system of mathematics education are obvious. The Third International Mathematics and Science Study (TIMSS) results released in 1998 showed "U.S. $12^{th}$ graders were close to the bottom in both mathematics and science" [2]. Enrollment in college mathematics classes continues to decline. Many Americans have negative attitudes toward mathematics: they say they don't like it, can't do it, or that it has very little use for anyone outside of the areas of mathematics and science. These negative views are reflected in pop culture when Barbie dolls say “math is hard” and beer ads conclude “if life were perfect, algebra would actually come in handy.” Obviously some students have been successful in the present system, but it should be clear that “mathematics instruction in the United States fails more often then it succeeds” [3, p. 169].

Calls for reform in mathematics education are not new, but in recent times the voices seem to have gotten louder. Where are these calls for change coming from and what are they saying? Certainly the most notable call for reform has come from the Standards documents published by the National Council of Teachers of Mathematics. Years in the making, these documents have assembled evidence from many sources to provide a comprehensive guide to help educators create a high quality mathematics education for all K-12 students. Along with setting standards, the documents recommend changes in pedagogy and curriculum that are necessary to achieve the stated goal that “all students should learn important mathematical concepts and processes with understanding” [12, p. ix].

In a speech to the Mathematical Association of America in August, 2000, Ohio State University President (and mathematician), William E. Kirwin, made a strong case for changes in mathematics education at the university level saying “only the *resistance* to change exceeds the *need* for change within our universities. For, like a series of comets striking the earth, external and internal factors are combining to alter the environments in which mathematics departments operate. Under these new conditions, we can either meet the fate of the dinosaurs, or we can adopt new strategies and thrive in the coming decades” [7, pp. 3-4]. Among his recommendations are reshaping the curriculum to include more active learning and applications, developing partnerships with other departments, delivering high-quality math instruction to nonmajors, adopting a goal of preparing excellent K-12 teachers, and making "a commitment to changing the department's role from an instructional filter to an educational pump" [7, p. 5].

Burger and Starbird have pointed out that "mathematics contains some of the greatest ideas of humankind" but most students are never exposed to them. They contend that all students can explore "deep fascinating concepts in mathematics" and students should never end their mathematics journey in dead-ends such as college algebra or precalculus. Creating positive attitudes toward mathematics is important if we want to increase enrollments and generate public support for mathematics education and research. Reform is a critical factor in the attitudes that our students will pass on to *their* children because "knowledge comes and goes, but hatred lasts forever" [1, p. 11].

In his classic work, *Mathematics in Western Culture*, Morris Kline shows that mathematics forms the basis for almost all areas of modern civilization, but few people today understand or appreciate the contribution that mathematics has made to modern culture [8]. Harald Ness, commenting on this conclusion, writes, "Unless we want mathematics to continue to be viewed as something distinct and separate from the mainstream of culture and consisting of a bag of clever tricks or skills, we must change the way we relate to the general public and the way we teach mathematics. We must view mathematics as an integral part of our culture and a significant force in our culture, and we must communicate this to our students" [13, p. 51].

These are just a small sample of the many voices calling for changes in mathematics education. As mentioned earlier, there are also voices, such as Mathematically Correct [11], calling for a return to the "Old Math". However, as I pointed out earlier, the "New Math" can hardly be blamed for the current problems in mathematics education when most students have been trained using traditional methods. In an article entitled "Parrot Math", Thomas C. O'Brien writes, "The back-to-the-basics approach to learning has been dominant in U.S. math classrooms throughout this century. The view of math as isolated bits of information to be transmitted to passive receptors continues to be dominant in America's schools. We cannot go back to basics as the critics demand. We've been there all along. And the fact is that the back-to-basics approach, not the activity based approach, has failed us" [14, pp. 435-436].

Now comes the difficult question: what can be done to really improve mathematics education. The quick fixes offered by politicians usually involve forcing students to take more math classes and punishing schools if their students fail to pass proficiency tests. Robert Davis of Rutgers University believes that "both of these directions for improvement are likely to turn out to make matters worse" [3, p. 165]. For instance, this approach does nothing to improve the mathematical knowledge or teaching methods of classroom teachers, which, as Liping Ma has pointed out, leaves much to be desired. John Desmond, in the November, 2002, issue of *NEA Today* points out four undesirable outcomes of the testing approach. "1) It trivializes knowledge and eliminates the concepts of understanding and perspective. 2) It narrows the scope of the curriculum to only those things which are tested. 3) It kills the creativity of those great teachers who understand what education is all about but who are pressured to teach to the test. 4) It destroys the curiosity of students by making the process of learning repetitive and tedious"[4]. Mr. Desmond feels that the worst aspect of this approach is that it institutionalizes the common American attitude that the main purpose of knowledge is material gain rather than providing the foundation for a meaningful life of vocation and service.

I believe one of the most promising options for improving mathematics education at all levels is the "humanistic" approach proposed by Dr. Alvin White of Harvey Mudd College in Claremont, CA. This approach is not new and variations of it have been used by good teachers since the time of Plato. Basically it involves teaching “humanistic content” using “humanistic pedagogy” in the belief that *lack of student motivation is the root cause of the literacy and attitude problems in mathematics education*. The movement “seeks to return to the educational process the excitement and wonderment of the moments of discovery and creation” [21, p. 130]. While individual teachers will use various methods to achieve this, some common characteristics of a “humanistic” classroom might include:

- Placing students in the position of inquirer, not just a receptor of facts and procedures;
- Allowing students to help each other understand a problem and its solution more deeply;
- Learning numerous ways to solve problems, not just an algebraic approach;
- Including historical background showing mathematics as a human endeavor;
- Using interesting problems and open-ended questions, not just exercises;
- Using a variety of assessment techniques, not just judging a student on his/her ability to carry out memorized procedures;
- Developing an understanding and appreciation of some of the great mathematical ideas that have shaped our history and culture;
- Helping students see mathematics as the study of patterns, including aspects such as beauty and creativity;
- Helping students develop attitudes of self-reliance, independence and curiosity.
- Teaching courses from a twentieth century perspective at the university level, so students have a grasp of the mathematics that is being used today in science, business, economics, engineering, etc.

Readers who wish to learn more about humanistic teaching are encouraged to read the book *Essays in Humanistic Mathematics* edited by Dr. Alvin M. White and published by the Mathematical Association of America [22].

Twelve years ago I began teaching at a small liberal arts college after teaching at the high school level for twenty-seven years. Several years ago the college adopted a policy requiring students with low ACT math scores to complete a college mathematics course before graduation. Since precalculus was the lowest level course offered by the Mathematics Department at that time, I offered to develop and teach a course (*Explorations in Mathematics*) for these students. I anticipated that these students would not be happy about taking a math course and subsequent surveys and tests showed this to be true. Even though almost all of these students had completed algebra I, algebra II and geometry, a pre-test showed that they had retained very little knowledge from these courses. When asked about their attitude toward mathematics, about 90% responded negatively commonly using words such as anxious, dislike, boring, hate, fear, stressful, struggle, etc. When asked about the importance of mathematics in modern society, most of those who were able to think of a response answered by saying that people need it to balance their checkbooks. Faced with this situation I decided to incorporate all that I knew about humanistic mathematics into the design of the course with two main objectives: (1) to enable students to succeed and develop some confidence in their mathematical abilities, and (2) to help students develop a more positive view of mathematics. I chose *Faces of Mathematics* [15] by A. Wayne Roberts as my basic text but modified some sections and added a section on computerized data analysis. Students also write two papers, one on the nature of mathematics, and the other on an interesting math problem, puzzle or historical event. They do an oral presentation of their second paper so the whole class can learn of some of the great ideas and events in the development of mathematics.

Last year the college dean suggested that I do a study to determine (1) do the students in my Math 105 (*Explorations in Mathematics*) classes perceive that the instructor is using “humanistic” teaching methods, and (2) does taking Math 105 result in a positive change in attitude toward mathematics? I designed a survey which was given to my Math 105 students on the first day of fall semester classes and a follow-up survey was given near the end of the semester. In order to have some basis for comparison of teaching methods, the same survey was given to all students who were taking their first math class at our college during the fall semester.

Since these other students were taking a variety of courses, no direct comparisons are possible. It was expected that students entering the higher level courses would have stronger positive attitudes toward mathematics since they had been successful in their college-prep courses. Only small changes in attitude would be expected in this group of students. Students entering lower level courses would be expected to enter with somewhat less positive (perhaps even negative) attitude scores and greater improvement might be expected. In particular, students taking the required Math 105 course were expected to have fairly strong negative attitudes, and it was hoped that the humanistic approach would lead to significant improvement in attitude scores.

After the survey results had been compiled, differences between the beginning and end of the semester were tested for significance using a dependent T-test at the 0.05 significance level. Since there were some students who dropped classes and others who joined late, the results were compiled using only those students who were in class for the entire semester. The survey results are summarized in the tables and graphs shown below.

**Table 1: Math 105 Attitude Survey Results**

| | Percent who Agree | |
|---|---|---|
| **Attitude Questions** | Beginning | End |
| 1. Math has played an important role in modern culture | 88% | 100% |
| 2. Math is an essential component of a liberal arts education. | 58% | 83% |
| 3. Math is mainly learning skills and memorizing techniques. | 63% | 54% |
| 4. I could easily name 10 useful applications of math. | 33% | 75% |
| 5. Ability to reason statistically is essential to be an informed citizen. | 79% | 79% |
| 6. Humanities deal with ideas while math deals with skills. | 33% | 25% |
| 7. There is beauty to be found in math just as in a poem or painting or music. | 17% | 50% |
| 8. Problem solving abilities learned in math classes are very useful in everyday life & work. | 67% | 75% |
| 9. If a person isn't born with math abilities, he/she will never be good at math. | 13% | 21% |
| 10. My math classes have usually been as interesting as my other classes. | 8% | 21% |

**Table 2: Comparison of Humanistic Factors in Math 105 to all Other Classes**

| **Humanistic Math Characteristics** | (% who agree - end of semester) | Math 105 | All other classes |
|---|---|---|---|
| 1. Students often placed in role of "inquirer". | | 73% | 67% |
| 2. Cooperative learning groups encouraged. | | 89% | 68% |

| | | |
|---|---|---|
| 3. Assessment done by a variety of techniques. | 86% | 57% |
| 4. Success requires understanding, not just memorization. | 86% | 87% |
| 5. Instructor was concerned about my success. | 76% | 71% |
| 6. Goal for the day clearly presented. | 97% | 83% |
| 7. Homework had interesting problems in addition to exercises. | 81% | 77% |
| 8. Instructor showed practical ways that math topics are applied. | 89% | 76% |
| 9. Topics placed in historical context to show why development was important. | 97% | 46% |
| 10. Students learned to appreciate creativity, beauty and see math as a human endeavor. | 81% | 57% |
| Mean | 86% | 69% |

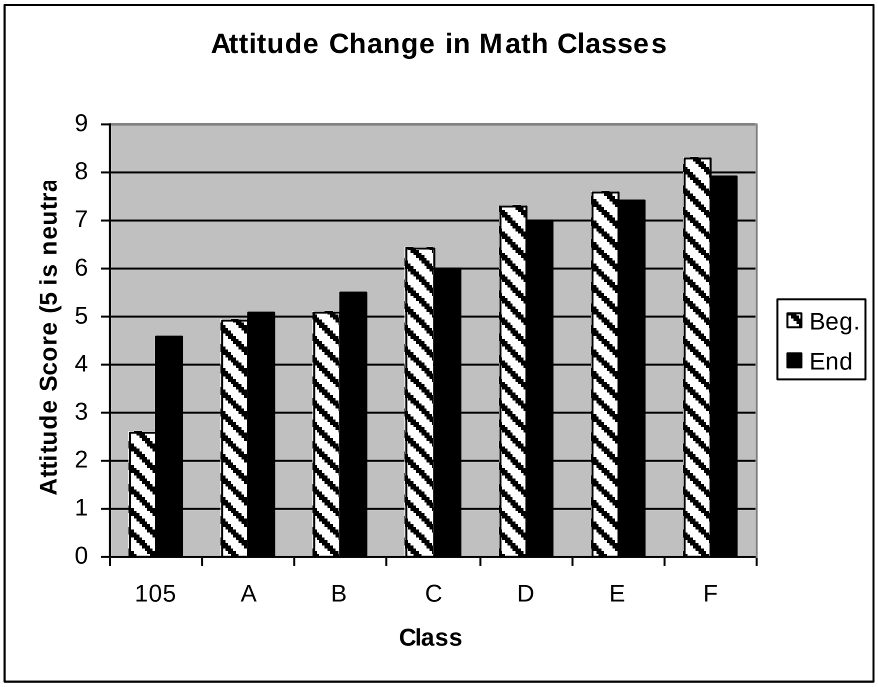
**Table 3: T-Test Results for individual attitude questions (Math 105)**

| | Attitude (0-10) | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beg. Mean | 2.6 | 3.0 | 2.3 | 1.3 | 2.0 | 2.9 | 1.9 | 1.3 | 2.7 | 2.7 | 1.0 | 21.1 |
| End Mean | 4.6 | 3.3 | 2.8 | 1.8 | 2.7 | 3.0 | 2.2 | 2.3 | 2.8 | 2.7 | 1.4 | 24.8 |
| Difference | 2.0 | .3 | .4 | .5 | .7 | .1 | .3 | 1.0 | 0.0 | 0.0 | .4 | 3.8 |
| Dependent T-Test (0.05 level) | **0.00025** | **.03** | **.01** | **.01** | **.001** | .29 | .09 | **.001** | .43 | .50 | **.01** | **0.0001** |

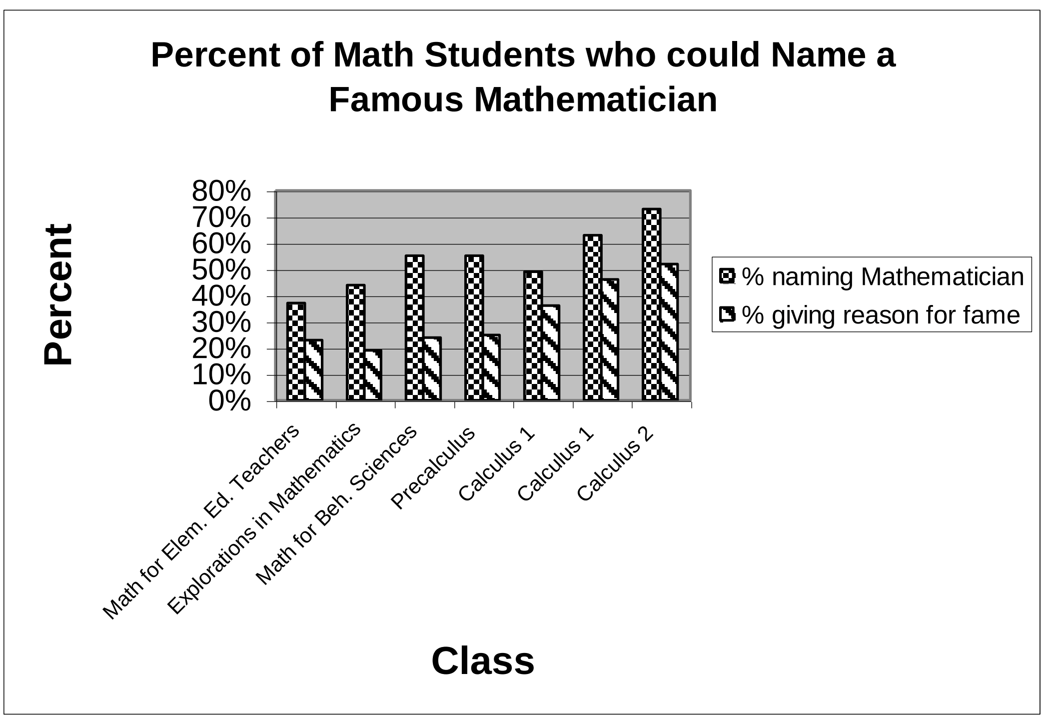
(Note: numbers may not add properly due to rounding by the spreadsheet)

**Table 4: T-Test Results for attitude questions (All Classes, excluding Math 105)**

| | Attitude (0-10) | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Beg. Mean | 6.5 | 3.2 | 3.0 | 1.6 | 2.8 | 3.0 | 2.1 | 2.4 | 3.3 | 3.0 | 2.2 | 26.5 |
| End Mean | 6.4 | 3.1 | 2.9 | 1.8 | 2.9 | 3.0 | 2.2 | 2.1 | 3.1 | 2.9 | 2.2 | 26.0 |
| Difference | -0.1 | -0.1 | -0.1 | 0.2 | 0.1 | -0.1 | 0.0 | -0.2 | -0.2 | -0.1 | 0.0 | -0.5 |
| Dependent T-Test (0.05 level) | .34 | .09 | .19 | **.04** | .08 | .26 | .40 | **.03** | **.004** | **.05** | .41 | .13 |




**Graph 1**




**Graph 2**

**Summary**

Table 1 shows the Math 105 attitude results as percentages of students who gave the desired response to the given statements. (Note that for statements 3, 6, and 9 the desired response is to disagree with the statement.) All except one moved in the desired direction indicating that student attitude toward mathematics improved as a result of taking the course.

Table 2 lists student responses to factors that the author considered relevant to humanistic teaching. The table compares Math 105 responses to the mean of all other classes that were surveyed. The mean score for the seven surveyed classes ranged from 47% positive responses to 86% positive responses. Based on the percentages, Math 105 students seem to perceive that the class is taught in a more humanistic manner than the other classes surveyed.

Table 3 shows the mean results of the attitude scale and the mean of the results for each of the ten individual attitude statements in the Math 105 survey. The differences in the pre and post results were analyzed using a dependent T-test at the 0.05 level of significance. The attitude scale was constructed with 0 as strongly negative, 5 as neutral, and 10 as strongly positive. The study shows an attitude change from 2.6 to 4.6 in Math 105 which was significant at the 0.05 level. For the ten statements which measured attitudes toward specific aspects of mathematics, the results were graded from 1 (strongly disagree) to 5 (strongly agree) except for #3, #6 and #9 where the numbers were reversed since the desired response was disagreement with the statement. Using this system, any positive difference means attitude improved and a negative difference means attitude has worsened. Note that improvement was shown in almost all of the results, and in 6 of the 10 statements the change was significant at the 0.05 level.

Table 4 shows the combined data for all the other classes surveyed (excluding Math 105). Note that all changes in attitude were small but most of the slight changes that did occur were in the negative direction. On the attitude scale, none of the 6 classes had a change that was significant at the 0.05 level. The T-test results for statements 1 – 10 showed 4 results significant at the 0.05 level, three of which were negative.

Graph 1 shows the attitude results for the seven surveyed classes. When separated by gender, females had a somewhat more negative attitude than males except in the Math for Elementary Teachers class. The initial survey also asked students to name a famous mathematician. If they could name someone, a follow-up question asked them to name something that this person accomplished. As Graph 2 shows, about half of the students couldn't even name one mathematician and only about half of those who could name someone were able to list an accomplishment. (Note: The most common response was Albert Einstein who was really a physicist but I counted him anyway!)

**Conclusions**

The study indicates that a humanistic approach to teaching mathematics can effect a positive difference in attitude for students who consider themselves "poor at mathematics". Perhaps if humanistic methods were used throughout a child's math education, fewer students would leave school disliking math or feeling that they "can't do math."

Less than 15% of high school graduates who go on to higher education ever enroll in a calculus class. Thus the humanistic approach would recommend that interesting and relevant math courses should be developed for these non-calculus bound students. A student's final math experience should not be precalculus or college algebra, courses whose basic purpose is to prepare students for the next higher level of math.

If mathematicians feel that humanistic methods cannot adequately prepare students for careers in math and science, then retain a traditional track for these students. However, educators have shown that humanistic content and teaching methods can be used successfully at all levels. Remember the purpose of the humanistic method is to engage and motivate students, so good mathematics students should thrive in an atmosphere where they are more free to inquire, discuss and explore.

It is also important to remember that teachers will need to apply these same ideas of creativity, exploration, discussion, etc. in order to transform their teaching to a more humanistic mode. They will first need to be convinced of the value of a holistic approach and then they will need some time and experience to determine how to best fit humanistic methods to their particular style and strengths. Dr. Roger Howe of Yale University underscores the need for teacher training if students are to see mathematics as a coherent whole. He writes, “To us it is one of the major attractions of the field: mathematics makes sense and helps us make sense of the world. For me, perhaps the most discouraging aspect on working on K-12 educational issues has been confronting the fact that most Americans see mathematics as an arbitrary set of rules with no relation to one another or to other parts of life. Many teachers share this view. A teacher who is blind to the coherence of mathematics cannot help students see it” [6, p. 588]. In view of the fact that many U.S. elementary teachers are inadequately prepared to teach mathematics and some even dislike the subject, the humanistic approach would recommend that elementary schools be departmentalized. The elementary teachers who have the best understanding of mathematics and who enjoy teaching it should be assigned to teach all the mathematics classes. Colleges should have programs to train elementary math specialists to fill these positions so that all students will eventually have a teacher who is knowledgeable and enthusiastic about mathematics.

"Students study the best paintings, the most glorious music, the most influential philosophy, and the greatest literature of all time. Mathematics can compete on that elevated playing field, but we must offer our students our grandest and most intriguing ideas. Infinity, fractals, the fourth dimension, topology, cryptology, and duality – these ideas and many more can compete well with any other subject for depth and fascination. In addition, the powerful methods of analysis that generated these fabulous ideas can enrich every student's ability to think. Mathematicians have a great story to tell and that story could and should be an important part of the education of all students" [18].

**Works Cited**

1. Burger, Edward, and Michael Starbird. "Abandoning Dead Ends: Embracing Lively Beginnings." *Focus: Newsletter of the Mathematical Association of America* 20:9 (2000): 10-11.
2. Cozzens, Margaret. "Learning From TIMSS-R about U.S. Mathematics Achievement." *Focus: Newsletter of the Mathematical Association of America* 21:5 (2001):28.
3. Davis, Robert B. "When is Calculus Humanistic?" *Essays in Humanistic Mathematics*, Alvin White, Ed. (Washington, DC: Mathematical Association of America, 1993).165-173.
4. Desmond, John. "Degrees in Thinkology." *NEA Today*, November, 2000, online edition.
5. Eves, Howard. *Return to Mathematical Circles*. Boston: Prindle, Weber and Schmidt, 1988.
6. Howe, Roger E. "Book Review: Knowing and Teaching Mathematics." *Journal For Mathematics Education Research*, 30:5 (1999) 579-589.
7. Kirwin, William E. "Mathematics Departments in the 21st Century:Role, Relevance and Responsibility." *American Mathematical Monthly* 108:1 (2001)1-9.
8. Kline, Morris. *Mathematics in Western Culture*. New York: Oxford University Press, 1953.
9. Lewellen, Hester. Department of Mathematics, Baldwin-Wallace College , Berea, Ohio (Presentation at the annual meeting of the National Council of Mathematics, Chicago, IL, 12 April 2000).
10. Lott, Johnny. "It's Time to Work Together*." National Council of Teachers of Mathematics News Bulletin* 39:2 (2002) 3.
11. http://www.mathematicallycorrect.com/
12. National Council of Teachers of Mathematics. *Principles and Standards for School Mathematics*. Reston, VA: The National Council of Teachers of Mathematics, Inc., 2000.
13. Ness, Harald M. "Mathematics: An Integral Part of Our Culture." In *Essays in Humanistic Mathematics*, Alvin White, Ed. (Washington, DC: Mathematical Association of America, 1993), 49-52.
14. O'Brien, Thomas C. "Parrot Math." *Phi Delta Kappan* 80:6 (1999): 435-437.
15. Roberts, Wayne. *Faces of Mathematics, 3rd Edition*. New York: HarperCollins Publishers, 1995.
16. Rothstein, Richard. "Lessons to Peace on Math's Battlefield." *The New York Times*, 27 June 2001, online edition.
17. Schmickle, Sharon. "Teachers Try a Calculated Bid to Break Math Barrier". *Minneapolis Star Tribune*, 4 November 2000.
18. Starbird, Michael. "Abandoning Dead Ends: Presenting the Heart of Mathematics to All Students." NSF Chautauqua Short Course, The University of Texas at Austin, May 23-25, 2002.
19. Steen, Lynn, editor. *Mathematics and Democracy: The Case for Quantitative Literacy*. The Woodrow Wilson National Fellowship Foundation, 2001.

20. U.S. Department of Education, National Center for Educational Statistics Pursuing Excellence. "*A study of U.S. Eighth Grade Mathematics and Science Teaching, Learning, Curriculum and Achievement in International Context.*" Washington, DC: U.S. Government Printing Office, 1996, Chapter 3.
21. White, Alvin M. "The Process of Education." *American Behavioral Scientist* 38 (1994):122-132.
22. White, Alvin M., editor. *Essays in Humanistic Mathematics*. Washington, DC: The Mathematical Association of America, 1993.