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# On Attracting Mathematics Majors

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**Acknowledgement.** I would like to mention my indebtedness to all my teachers, throughout my life, and to all my colleagues and students at Potsdam, who showed me that there are a variety of methods of teaching mathematics which work. A special note goes to Clarence Stephens and John Poland who helped me to find the probable factors which are involved in attracting students. I would also like to thank Charles Smith, Benjamin Brewster, Leona Ludwig, Irene Schensted, Dilip Datta, and Vasily Cateforis for reading this manuscript and making many valuable suggestions.

I want to consider what factors are involved in attracting students to mathematics. Several of these factors have become evident to me from observing and participating in the Potsdam College mathematics program, where I have been teaching for the last nine years.

Every teacher first of all is a product of his/her teachers and his/her students. When we are in the classroom sometimes we play the role that our previous teachers played. We usually imitate those we liked the most, but sometimes we imitate the ones that we did not like at all. This is both good and bad. Our students are inevitably exposed to our philosophy of teaching. Our students also influence our teaching. They can encourage or discourage us. As we all know, they can make the classroom a pleasant or miserable experience for us. Hence instead of talking about teaching I would like to talk about the factors that probably make the interplay between student and teacher a pleasant and successful one. One observes that while some students are successful with certain teaching methods they are not as successful with a different teaching method. For example Hector Foisy's method of teaching in Potsdam is as effective as Clarence Stephens' method of teaching. Yet the two of them have different ways of teaching. Each of these methods attracts its own group of students. Therefore it is good that in a given department there are different methods of teaching. Enforcing just one method of teaching in

a department is only going to attract certain students, those that respond to that certain method.

Let us first start with the nature and psychology of human beings. Some people seem to be born with a natural ability to survive and be mathematicians, like Ramanujan, Galois, Sophie Germain, etc.... They survive even when academia has not been appealing to them and has not provided a positive environment for them. We must leave this to biologists, to find out why some

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people are born with this natural ability. Maybe in the future one can walk to a clinic and have his/her brain set in this way. Some others, perhaps not as talented as the first group, have enough energy, motivation, and willpower to go on regardless of the situation and their instructors. Their hard work compensates for their lesser talent. Academia has accommodated them and has been good to them. We will leave this to psychologists to find out why some people become like this. Maybe in the future one can walk into a psychologist's office and get enough energy and willpower and motivation. These two groups need challenge and opportunity.

In contrast to these two groups, I believe there is a third group that will survive if a nurturing, encouraging and understanding environment exists for them. This is the group that depends on us. As instructors, we can attract them to mathematics or turn them away. For people in the first two groups I see, among other things, an intense love and desire that drives them. We need to create a desire and interest in the third group. To



identify some factors that create this interest and desire in students, we will discuss the roles of the following: proper goals, instructor attitude, instructor's maternal/paternal advice and help, department, school, positive publicity, awareness of the student, economic situation, culture, and role models. Some of these factors cannot be influenced by us. We should find out what we can change and control and what we can not change, and must accept. One can see that goals, teacher's attitude toward students, department, positive publicity, role models, awareness of the students and to some extent school can be influenced by us. However, social factors, social values, economic situations and human nature cannot. Now we look at the effect and the role of each of these factors in more detail.

**(i) First we would like to clarify the effect of goals:**

What do we want to achieve by teaching and what do we want to achieve in particular by teaching mathematics? Is the aim of teaching mathematics to cover certain material and make sure that students know these certain materials, or can there be other goals? My experience at Potsdam indicates there can be other goals. What if we set the following goal of teaching: after taking a course in mathematics the student should wish to go on and choose another course in mathematics or to continue toward graduate school

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or to continue to be a scholar in mathematics. In other words what if we cultivate the student's interest in mathematics? Let us for a moment, pause and see what we achieve by choosing such a goal. If a teacher goes to the classroom with the

goal that he/she is going to cover certain materials and addresses only the brighter students in the class, then my experience says by the end of the course, more than half of the students may drop out and some of the handful that manage to pass the class may not be willing to take another course in mathematics. These students pass the course in spite of the instructor. The probable outcome of this approach is obvious. There will not be many people who want to become mathematics majors. This may be the reason you are reading this article. So, let us look at the other goal: that a majority of the students, taking a course in mathematics become interested in mathematics, choose to take another course in mathematics, and pursue mathematics on their own. Although the instructor has not covered as much material as those with the first goal, the student continues to take courses in mathematics. The student that has been taught one or two chapters fewer in every mathematics course, has survived the courses and become interested in mathematics, may even earn a B.A. in mathematics. Now the student has the mathematical maturity to read and learn quickly the missed materials. Therefore we as teachers have not hurt the student by teaching the student less material but have actually helped the student to become a mathematician. Is not this what we really wanted to do? When we teach a three semester hour course we only have 45 hours for a semester, less than 2 days. The amount of material that we can teach in this short time is very limited regardless of how fast we try to go, especially considering the total amount of mathematics that there is out there. But if we can inspire our students so that many of them continue taking and pursuing mathematics, then we have created mathematicians.

We cannot rely on performance in certain tests and examinations to judge if we have fulfilled such a goal. If a student develops the interest to continue his/her scholarly activity we have achieved our goal. We believe that we have students drawn from the best generation that the world has ever had and it is our duty not to mold them but to create an interest inside them, give them confidence and build their brains. To accomplish these tasks we need to approach them with the right goal and create an atmosphere for them to learn and enjoy mathematics. Testing them is doing nothing more than making them anxious and fearful and nervous and ruining their creativity.



**(ii) Now Let us look at the role that instructor attitude plays:**

When we as instructors go to the classroom, if our attitude is to find a way that helps our students to learn and enjoy mathematics, to learn how to learn, then the probable outcome would be good. If we go with the intention of creating an atmosphere that is motivating, relaxing and understanding of the student's abilities, then the probable outcome will be to attract students. If we go to the classroom with the intention of creating confidence in them so that they are able to do mathematics and they also can enjoy mathematics, and thereby gain confidence, then the

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**Learning mathematics is like learning to walk or learning to talk. It needs patience, practice, desire, and a relaxing and nurturing environment.**

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outcome will be great. The attitude that conveys to students that mathematics is only for the elite, that they are unable to be successful since they are making mistakes, the attitude that half of the students should drop out since they can not keep up with the teacher is probably not going to attract students to mathematics. The attitude sometimes seen in our coffee room discussion, making fun of their mistakes, is going to have a probable outcome of scaring students away from mathematics. It is this attitude that engenders comments from the students that mathematics is hard and not for them; it is only for geniuses.

The first day of class can be crucial. If an instructor goes to class and draws the line, puts students down, threatens them, uses grading to create fear in them, makes them worried, gives them the statistics that so many of the students who take this course drop out, tells them that the subject is very difficult, and conveys to them that they are not able, then the outcome is obvious. But suppose from the first class the instructor tells them that he/she is there to help them, to create an interest inside them, to help them to learn how to learn, tells them the grade is not the best thing that

they can take out of the class, tells them this class can create a love for learning in them, tells them that to learn mathematics they need to be patient and persistent and have proper scheduling and practicing, tells them that becoming skillful in mathematics is like becoming a wrestler, a runner or a swimmer, tells them that there is also joy in the learning of mathematics. Such an instructor will notice that fear and anxiety have been replaced by a desire for learning. This can be seen in the way that they are sitting (they are all ready to go and learn).

A very bright student in an elementary course drew my attention and I tried to encourage him to take more math courses. The student told me that he knew basic Algebra when he was four years old. But when he got to school, his teacher's attitude turned him off from mathematics. Then he decided not to pursue mathematics any further. The course that he was taking was very easy for him and was part of the requirements; he had to take it. Of course we have had cases that regardless of how much the situation has discouraged students, they have continued and contributed. I do not think I need to mention them here as we all know them. We all know the ones who survived. The ones that have not survived are more hidden, and sometimes it has been because of us. We can change this.

We might be criticized that not all of the students in this system will turn out to be high caliber mathematicians. I would accept this, but I would argue that some of them might go as far as a B.A. in Math, some of them might have another major or another interest, and some of them might go as far as a Ph.D. But a student who is majoring, say, in economics and also has a B.A. in mathematics will definitely be a more effective economist. A representative of a company that was on campus to hire an economics major said that economics majors who are also mathematics majors are very good problem solvers in the sense that in many situations their training in abstract mathematics helps them to look at the problem in a better way. Or somebody who will become an elementary education teacher with a B.A. in mathematics can be a more effective teacher than one with only the minimum requirements. In a traditional approach, these students would not go beyond the courses that were required of them.



**(iii) Now let us look at the factor of the Instructor maternal/paternal advice and wisdom:**

The impact that we have on our students is not just in the mathematics that we teach them. A look at classroom surveys and talking to students after classes indicates that we have some other impact on our students. Our words can help them and sometimes can change them, our actions can have an impact on them. Over the years as some of our Mathematics Alumni come back to visit us or write to us, they attribute their success to certain words that a certain professor told them or help that a certain professor provided. Somehow those words or help had an impact on them and created enough fire inside them to help them finish their degree or continue their graduate work or assist them in their professional life.

Let me give you a few examples to clarify what I mean by paternal advice and wisdom. A student who is very frustrated and cannot prove theorems tells the instructor she cannot do mathematics, she is not good enough even to finish the course in mathematics. And consider two instructors with two different approaches. The first one tells the student that it is probably a good idea to drop the course and conveys a message that the instructor and people who do mathematics are indeed very smart and they were just born with this ability. After a few minutes the student leaves the office of the instructor. The student will probably never take any more mathematics courses. Now let us look at some other instructor who is more helpful. He asks the student how long it took the student to learn to speak the way that the student speaks today, how long it took the student to learn to walk. Then the instructor tells the student that learning mathematics is like learning to walk or learning to talk. It needs patience, practice, desire, and a relaxing and nurturing environment. It needs persistence and time. This makes the student feel better and more aware. Now the instructor asks the student whether she is overloaded, whether she has somebody that she can work with, whether the student would like to join a study group. And the outcome: there is a chance that the student will survive the mathematics course and even take more mathematics courses.

Let us look at another case. A student who is taking a mathematics credit on an independent study does not do well in his first presentation.

The student complains that he cannot understand the subject. Let us look at two different instructors. One instructor tells the student that if he is not doing well now he will probably get a bad grade or fail and then the instructor does not think about the student anymore. The outcome is probably that the student will fail or drop out and it could be his last mathematics course. Now let us look at another instructor who is more helpful. At first, this instructor may not know how to answer. He starts thinking about the student and starts searching for a way to help him. In the middle of the week the instructor has a brainstorm. He calls the student. The instructor tells the student that he just called to see how he is doing, whether he still feels stuck and gives a few words of fatherly advice. Students respond to this type of specific attention, and this student tells the instructor that he is going to pick up the book as soon as their phone call is over. The instructor realizes that the behavior of the student has changed and soon he is

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doing much better. Of course different instructors might come up with different methods to approach these problems. But it pays off if we think about our students and try to find some solutions rather than blaming students' low performance on their inability. A mathematician once told me that his teacher, in a geometry course in high school, told him that it is good to take a problem in geometry and think about it an hour or so per day, in a relaxed manner, until the problem is solved. Then take another problem. The instructor told him that this will also help to build his brain. Although this student usually did not take the instructor seriously, he took this advice seriously. He felt it was instrumental in helping him to become a



mathematician. We all know of examples of students for whom some teacher made an important difference. We can be effective and make a difference for many of our students, with the right attitude.

**(iv) Let us now look at the effect of role model:**

We are motivated to do different things by our inner interests or the joy that we get. We can affect our students by our interest in mathematics, provided that we use this interest in a proper way.

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**I am not saying that mathematics is easy. What I am trying to say is that mathematics is useful, and joyful, and can be learned. Our students need at least to feel the joy of mathematics.**

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By this I mean using our knowledge not to make them feel inferior and unable, but instead using our knowledge of mathematics to create an interest and desire inside them, convey our pride in mathematics to them, convey our joy of doing mathematics. Imagine what would happen, if our mass media would publicize mathematicians, if they ran programs in which the eminent in the field would convey to the public their joy of doing mathematics and the usefulness of mathematics. This might help to attract more students to mathematics. Many of our mathematics majors do not know of Hilbert, Emmy Noether, Poincare, Sophia Germain, Gödel and so on, nor who the current eminent ones are or even what a Fields Medal is. Many people do not know that doing mathematics can be joyful and rewarding. We can play a good model for our students. Here a true story might help. One of our recent undergraduates said the reason that he decided to go to graduate school and become a mathematician was that he wanted to become like Paul Erdos. The student had read and heard about Erdos, and this story had created a fire inside him. Erdos was his hero.

**(v) Effect of awareness by students of opportunities for mathematicians:**

Many students are not aware of opportunities for a mathematician to have a job beside teaching. There are also many mathematics majors who are not aware of financial opportunities that are available for them to go to graduate schools. In Potsdam college we announce jobs that our graduates have had and a newsletter about our alumni. Some of us also talk to the students that we see are able to go to graduate school and inform them of the financial opportunity that is there. We find that they are very surprised to hear that they are paid to go to graduate school.

**(vi) The effect of positive publicity:**

There are lots of rumors that mathematics is a boring, joyless and useless subject. These can influence our students before they arrive in our courses, and are driving many others away from even attempting college mathematics. But we can create a more positive, interesting, useful, and appealing image of mathematics. When we ruin one student who we could have saved, we turn hundreds away by negative publicity. It is rather alarming that when we speak to virtually anybody who is not a mathematician, the person considers mathematics useless, hard and boring, and considers herself/himself unable to do it. It seems that the word "mathematics" creates a kind of fear and anxiety that prevents a student from approaching it with an open mind rather than prejudiced. This prejudiced mind will make it even more difficult for a student to learn mathematics. I can not resist telling this story: once upon a time a teacher told his students that their next test would be difficult and most of them might not be able to do it. Then he gave them an easy test. But he had created an image of a difficult test so that some of the students insisted on giving complicated answers to the simple questions that had nothing to do with the questions. They could not see that it was simple.

I am not saying that mathematics is easy. What I am trying to say is that mathematics is useful, and joyful, and can be learned. Our students need at least to feel the joy of mathematics. They need to be assured that with some effort they can learn to learn independently



of whether they get interested in it or not, or whether to devote their life to it or not.

**(vii) Effect of culture on education:**

Culture creates values and guidelines which can have either positive or negative effects since these values and guidelines create pressure. This pressure sometimes is visible and sometimes invisible; it can be helpful or not helpful. The reason that culture can play this dual role is that it is based on the past rather than the future. I remember one person who told me that she wanted to become a mathematician and liked mathematics very much, but her family wanted her to become a chemical engineer because they thought chemical engineers had higher status. She became a chemical engineer just to keep her family happy. Another student reported his parents told him that either he should go to the best mathematics department or he should not go to graduate school at all. He went to the best department but could not survive. Then he quit graduate work in mathematics altogether, although he might have survived if he had gone to a less competitive, smaller school.

There is pressure on students from family and from society. The weaker the students the more vulnerable they will be to this pressure. A female student of ours said that when she was a student in high school her teacher constantly made negative remarks to the effect that female students do not succeed in mathematics. Fortunately this student did get her B.A. in mathematics; she was among our better students. I am sure that this high school teacher discouraged many other female students from following their interest in mathematics. We have had female students that wanted to go to graduate school to continue mathematics, but were being discouraged by friends and family: They were told they should get married or find a job rather than go to graduate school. With some effort from some of their instructors, some decided to go to graduate school but some did not. One of our students said she did not want to go to graduate school because she was under pressure: going to graduate school meant she could not have a family and children. But after her instructor told her that there is a life after graduate school and she could have a family and children after she got her Ph.D., she became convinced to go to graduate school. A guideline of

the past was misdirecting her. Or consider the simpler case of a student who did not want to study that much because she did not want to miss having fun. However, she was told first that studying can be fun and second after school there is also life and she can have fun then, too. This was a revelation to her. After this conversation she was a more serious student. Pressure or culture of the dorm was not letting her see other values. Yet another example: A group of friends were not doing well, because they were trying to have fun together primarily by getting together to drink. One of their instructors suggested instead they have fun by studying together, or they could get together and discuss an agenda together and have fun this way. These words were a revelation to them. Some of them became better students afterward. What I want to convey is that we have to counterbalance harmful social customs.

**(viii) Now let us look at the role that the department can play:**

The effect of departmental policies is not something that can be overlooked. The department needs to create a proper environment in which the faculty can develop both in their scholarly activity as well as in their teaching methods. The department needs to provide help, encouragement and orientation for faculty members in need. In a department in which faculty energy is consumed by politics and bureaucracy, and faculty is stressed by

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**In a department where the faculty is overloaded and not respected, where faculty is expected to do the unexpected, one cannot hope that faculty will function properly.**

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guidelines then true scholars may be looked down on, and faculty will be less able to help students. In a department where the faculty is overloaded and not respected, where faculty is expected to do the unexpected, one cannot hope that faculty will function properly. One uncomfortable faculty member can make hundreds of students



uncomfortable. The thing that drew my attention to Potsdam College Mathematics Department, when I was there the first year, was to hear the chairman, Clarence Stephens, constantly saying that "we need to cultivate a culture of using our brains to help students by providing a proper environment for faculty". Charles Smith, a senior faculty member who kindly took charge of orienting me assured me that the Department was very considerate of the faculty and an example of this helpfulness was that those few of the tenured faculty that did not have a Ph.D. in mathematics were encouraged and given proper help and the environment to work toward their Ph.D. This made me feel at home right away. What we want to convey here is that a proper and humane management of the department is very necessary and should not be overlooked. Of course, a department in a school whose administration is not understanding is bound to be less effective. The administration needs to be in communication with the department. The administration needs to be helpful and in turn, faculty need to be ready to orient and guide the administration when necessary.

#### (ix) The effect of economic factors:

The following true story might clarify the effect of the economy on mathematics. One day, one of our better mathematics students, who had applied to graduate school and also had an offer for a good paying job, went to the office of one of his instructors. He wanted to get some advice about whether he should go to graduate school or join the work force. The instructor tried to convince him to go to graduate school. At one point he asked the professor about the beginning salary of an assistant professor. It was less than what the student was being offered. The professor could see that as soon as he found out about the salary of an assistant professor the student had no interest in going to graduate school any more. This might be one reason, among other reasons, that we do not have too many mathematics Ph.Ds. What do you think would happen if the beginning salary of an instructor in mathematics was \$200,000 and he/she had a personal secretary and a fancy office?

I would like to conclude with the statement that there is no known perfect system or method of teaching, managing, advising, and caring for students. Every method regardless of how humane could alienate some students. Therefore, different methods, in a given department, will accommodate a wider spectrum of students. In addition, students need to be informed that the teacher is not the only one responsible for their education. They need to take responsibility too in order to make the event of student-teacher interaction a successful one. By this I mean that they need to be treated like mature adults and given respect. A classroom is not just a teacher who is standing there, anxious to teach and to finish certain materials. It is a student-teacher event. Therefore the teacher should avoid conveying to the students that she/he is the one that feels the entire responsibility for the students to learn and the students need not feel any responsibility. I have noticed that when a teacher mentions to the students in class that it is the students who are the ones that are paying money and the teacher is the one that is paid, students become more aware and act more responsibly. The first year that I was in Potsdam College, I visited some of Clarence Stephens' classes. I noticed that among the many good things that he was doing, one was that he was allowing his students to feel that they were responsible for their own learning.

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Editors Note: For historic and pedagogic interest, two essays about the Potsdam Program that appeared in HMNN#2(March 1988) and HMNN#3 (December 1988) are reprinted following this essay.