CAN WE TALK? USING TECHNOLOGY TO ENCOURAGE COMMUNICATION.

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Why are we talking about communication in mathematics classes? Several years ago I started teaching our University Seminar classes and developed major specific sections for our math and digital forensic students. The final for the class was to write a paper and give a presentation on a career in their respective majors. In doing this, I noticed a trend. Almost every career required communication, both written and oral, as one of their top soft skills. With a little research, I found that, according to National Association of Colleges and Employers, 95% of employers consider communication skills as essential, The National Council of Teachers of Mathematics believe communication so important that they have listed the skill as one of their five processing standards. According to the Job Outlook survey of 2018, only 41% of employers feel new hires are proficient in this area. So if communication is so important, why are we failing our students in this area? Fortunately, communication is a skill that can be learned, and we as educators should try to help our students achieve every advantage possible. Therefore, we need to learn to incorporate communication into our mathematics classrooms and not rely solely on other fields to teach them these skills.

So how do we incorporate communication in a math classroom? We need to learn to change our vocabulary and include words like “explain”, “how”, “describe” and “why” in all of our classes, not just the courses that involve proof. A simple way to incorporate communication is having students present their solutions on the board, making them explain each step. Another is to add questions that involve “explain your reasoning”, “describe the method you used”, etc. These are simple changes that get your students to start to think about how can I explain the way I solved the problem, in other words, communicating their methods. I am always asking my students “How would you explain solving this problem to your grandmother?” They need to stop using technical language and bring the conversation down to a level that those who are not in the class and do not have the same experiences can understand. This is the audience they will face in the real world.

Another method is to incorporate activities into your classes. In particular, using technology to explore more diverse and realistic questions that you may not be able to do by hand. There are different types of activities that can be included such as discovery, research, or application. Here we will discuss a few examples to help get you started on how you can use technology to increase the level of communication in your math classes.

First consider discovery activities. Discovery activities involve the students making conjectures from observations and then trying to justify and prove those conjectures. A simple discovery activity that I do involves special quadrilaterals and Geometer's Sketchpad. The students are given the most basic definition of parallelogram, rhombus, rectangle, square, kite, trapezoid, and isosceles trapezoid. Then they use Geometer's Sketchpad to construct these shapes, take measurements of angles, sides, diagonals, and segments to determine any properties these quadrilaterals may possess: are there any congruent angles; are there complimentary or supplementary angles; are there congruent sides; are diagonals congruent; are they perpendicular; etc. Using the software, they are able to manipulate their figures to see many examples quickly to help them formulate their conjectures, something they are not readily able to do by hand. Once they have their conjectures, they then have to verify if those results are true. Can they prove or explain why, or must they construct another example that would violate their conjectures, and if so, what is different about the two examples? Without the software, students are not able to manipulate figures and often miss properties or add invalid conjectures that they cannot disprove. Having to validate or disprove their conjectures gives the students the opportunity to communicate their results either in writing or presentations to the class.

The second type of activity is a research paper. Depending on the topic, the papers can lead to discussions on different mathematical subjects. One paper I have students write is on an application of the subject of the class, for example how is trigonometry used in the real world. The students must get their topic approved and then write a paper on the subject. This answers the common question, "where will I ever use this?" Once the papers are done, I share the list of topics chosen by the students with the class, everything from surveying to construction, sports to radiation treatments. This invariably leads to the discussion of "I never knew math had so many uses."

Another possible research paper is to give students data and conclusions drawn from that data. They then research to see if those conclusions are accurate or if there are other factors involved. As we all know, people can manipulate data to support almost any outcome if they do not care about the accuracy of the results. One example I use is determining if wolves are the reason for the decline in the elk population in the Yellowstone region. They are given data and then asked to research what other factors may play a role in the decrease of the population, or if the original conclusion is accurate, that wolves are to blame. For this, I usually have the students working in groups, so I don't have to read thirty or so papers on the same topic. These papers can lead to discussions about predator/prey dynamics, exponential functions, and analyzing data. Being able to use the Internet allows for these types of explorations that wouldn't be possible without technology.

The third type of activity, which we are most familiar with, is application based. Technology not only allows us to do more complex and/or realistic problems, but also problems that are relatable to the students. For example, an activity called "Ski Patrol Rescue" may be used. Living in the northeast, we have a lot of snow and skiing is a common winter activity. If you live in a region without snow, you can change the

scenario to hiking. The idea is that a storm is moving in and the "local" ski resort is closing. Just as the last two ski patrol members are about to leave, they get a frantic phone call from a skier who has a broken their leg and is still on the mountain. Before they can reveal their location the phone cuts out. How are you going to find and rescue the skier? The only restriction is that ski patrol members must remain together so they can search both sides of a trail at once, to be sure neither is left on their own in case of an emergency. Each group of students is given a different mountain to work with and it is up to them to find a map of the ski resort, convert that to a graph, and then determine the most efficient method of solving the problem, which we know is an Euler circuit. Some groups find technology that will convert their slopes to a graph automatically, while others trace them. Some students research the slopes that are more popular and start their circuits there and others work more in a left to right pattern. After they have solved this problem, they are then asked how the solution would change if there were four or even six ski patrol members. In all of this, they need to explain their process and the methods they used.

Another example that students of all ages love is cryptology, or the act of sending secret messages. Here, depending on the coding method, students may only need a simple calculator or they may be able to do the method by hand. There are encryption methods that use matrices, which relate to systems of equations; binary, which is base arithmetic; trees, demonstrating tree searching; etc. The point is that data encryption is more vital than ever in our society and the students enjoy learning about ciphers. So how does this relate to communication and technology? The second part of the assignment is key. Depending on the class, after we have done a few coding methods, I have the students research either how coding and data encryption is used today or research a cipher that we have not discussed and explain how that coding method works. In both instances, students are doing research and writing in their math classes. If appropriate and time permits, I have the students work in groups and then teach their ciphers to the class.

Incorporating communication into the mathematics classroom requires us to make small changes that can have a big impact on our students. Communication is a skill that when practiced will improve over time. Anything we can do as educators, to help our students succeed, is important. Changing our vocabulary to include words such as "explain" and "describe" will benefit our students. It is just as valuable for our students to be able to explain their answers, as it is to solve the problems themselves. Getting a correct answer with no real understanding of the process, means that in the long run they will not remember or be able to solve more complex problems in the future. We cannot be afraid to assign papers in our classes just because math is the subject. Writing assignments should not be reserved for the humanities alone. Being able to communicate mathematical concepts in a way that is understandable to people in general will help our students in their respective careers. Incorporating technology gives us the freedom to do work on bigger problems with more realistic numbers and data. Most importantly, getting students to talk and write about math and its applications will not only improve their communication skills, but will give them a greater understanding and appreciation of the subject itself.

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