WRIT: Journal of First-Year Writing

Volume 1 | Issue 1 Article 3

9-2017

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Recommended Citation
Moore, Luke (2017) "Improving Science Classrooms by Asking More Beautiful Questions," *WRIT: Journal of First-Year Writing*: Vol. 1: Iss. 1, Article 3.
DOI: https://doi.org/10.25035/writ.01.01.03
Available at: https://scholarworks.bgsu.edu/writ/vol1/iss1/3

Improving Science Classrooms by Asking More Beautiful Questions

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I am currently enrolled at Columbus State Community College and will be working towards an Associate's Degree in Science, after which I will transfer back to BGSU and work towards my Bachelor's in AYA Life Science and Chemistry. The goal of the essay was to inform readers about the importance of questions in the field of science and teaching, and how I plan on using them when I become a teacher. As I continue in college, I plan to add and adjust how I can better teach my students by engaging them with questions.

Which is faster--the speed of light or the speed of sound? Of course, the answer is the speed of light, traveling approximately at $3.0x10^8$ meters per second (186,000 miles per second), with sound traveling at 340.29 meters per second (761 miles per hour). "Of course, the answer is the speed of light," you might say, "Everyone knows that!" The numbers may make it obvious to see that one is much faster than the other, but few people can grasp how fast light truly is. To put it in perspective, light traveling in a vacuum would be able to travel around the circumference of Earth (24,901 miles) a total of 7.5 times in one second. Now, I think that is cool and interesting to know, but apparently, some people don't think it as interesting as I do. For example, while playing a card game with some friends, one friend said that the speed of sound was faster than the speed of light. After quickly correcting them, it got me thinking as to why they had thought this? How could something so fundamental to the field of science be confused like that? So, I asked them why and they responded by saying it never mattered to them which was faster, and that it wasn't that interesting. That answer shocked me, but also helped me in a way. I began to ask myself questions as to why my friend did not understand or remember this constant. Questioning further, I found that many other students had the same problem of a lack of interest in some topics of science. For example, before speaking to an audience during TedxVienna, Michael Stevens, creator of *Vsauce* and co-host of *BrainCandy Live*, asked someone backstage if they knew why the sky was blue. Their response was that they couldn't remember because it did not seem important at the time. He later goes on to explain to the audience that the reason that the sky is blue is the same reason that blue eyes are blue: Rayleigh Scattering. So, why do people seem to lose interest in information? Are students not interested because the teachers do not attempt to engage them? Questions like these, along with many others that earlier as a child, helped me reach where I am today: an aspiring science teacher. As an aspiring teacher in the field of science, I want to find out how best to teach my students so that they can retain the knowledge that I introduce to them; however, doing so first requires me to ask the right questions. These questions can include: "How can I make a good lesson plan?" "How do my students learn best?" "How should I teach my students?"

How Can I Make a Good Lesson Plan?

In all my internships, field experience, and education classes, there has always been one constant that teachers must do to get students to understand and learn. Teachers must have a good lesson plan so that both teachers and students can keep on track. "How can I make a good

lesson plan?" One of the best ways I have found to form a lesson plan is to use the 5E Model. This model includes five steps: Engage, Explore, Explain, Extend, and Evaluate. The first step, Engage, is designed to present the students with activities that will capture their attention, stimulate their thinking, and help them access prior knowledge. Teachers can use the Engagement step by starting their lesson with a simple presentation or experiment and asking students questions on why they might think the experiment is reacting the way it is. Teachers should allow the students to wonder and predict, encouraging questions and creating an environment in the classroom where the students can feel safe to speak up. However, teachers should not answer any of the questions. By not directly answering the students, it forces them to wonder and question their own theories and begin to construct their own answers based on observations and background knowledge. It is also important for teachers to encourage students to come up with their own ideas so that students will begin to understand that there are no wrong answers. The second step, Explore, gives students the time to investigate the presentation, activity, or experiment on their own. This independent exploration can allow students to do their own research into questions or theories as to why the experiment reacted in such a way. For example, students could be presented with an experiment or activity during class that had properly engaged them. Upon returning home or having time to settle down, students could research and possibly attempt to replicate the activity in hopes to better understand it. The third step is to Explain, focuses students' attention on the engagement and exploration stages, giving students the chance to demonstrate their understanding of the lesson. The Explain stage also allows teachers to introduce a concept, process, or skill and students can explain their understanding of the concept. This stage can be used to answer many of the questions the students may have originally had. Afterwards is to Extend, which means allowing the students the opportunity to expand and solidify their understanding of the concept. Teachers challenge and extend students' conceptual understanding and skills and through these new experience, the students develop deeper and broader understanding. This stage can also lead to giving examples of the concept in real world situations and connecting the concept to the students. The final step is to Evaluate the students understanding of the lesson. Teachers are given the opportunity to evaluate student progress toward achieving the educational objectives. The evaluations done throughout the lesson are known as formative assessment. Formative assessments usually take the form of quizzes and rubrics to allow students to test themselves and see where they stand. If students find that they are falling behind or are having trouble grasping the concept of a specific part, the teacher will be able to see and then can ask students if they need help on any specific question or if they would like a review. Teachers should also evaluate them at the very end, whether it is for the students to replicate or make their own activity based on the initial experiment or simply by taking a test. Each of these steps help form a structure that teachers can use to format their lesson plans, which help guide students to asking more beautiful questions in the classroom.

How do my Students Learn Best?

To truly understand how to teach a classroom of students, it is imperative that the teacher understands how each student learns and how to adjust their lessons accordingly. Each student learns a different and specific way, and one of the hard things about being a teacher is that the classroom will change. "How do my students learn best?" Howard Gardner, an American developmental psychologist and professor of Cognition and Education at Harvard University,

https://scholarworks.bgsu.edu/writ/vol1/iss1/3
DOI: https://doi.org/10.25035/writ.01.01.03

theorized that students had seven distinct intelligences and "therefore learn, remember, perform, and understand in different ways" (Gardner). These different intelligences, known as multiple intelligences, can help students identify their understanding and how best to work with them. *Visual-Spatial* dealt with students who learned best by a seeing or sketching out a plan. These students may require a teacher to show examples or to walk through a problem step-by-step. *Bodily-kinesthetic* was seen in students that understood best when interacting with objects, preferring a more "hands-on" approach to learning. *Musical*, another of Gardner's intelligences, is often associated with students who seem to enjoy music or are sensitive to sounds in their environment. They tend to perform better when there is music in the background or with headphones in. *Interpersonal* describes when students are more understanding of others and tend to learn best when provided group work with other students. These students tend to be more social and enjoy communication. *Intrapersonal* is the opposite of interpersonal, where a student understands their own interests and goals. These students may come off as shy and can learn best from independent study. *Linguistic* describes students who possess "highly developed auditory skills and often think in words." They tend to enjoy reading and can be taught by encouragement. Finally, *Logical-Mathematical* describes students who can think critically, conceptually, abstractly, and can see and explore patterns and relationships. They need to learn and form concepts before they can deal with details. It is important for a teacher to be able to identify these seven intelligences in their students because it allows me to make changes to the way they teach so that their students can better learn and understand the lessons. Students that can identify themselves can assist by asking questions that align with their portrayed intelligence(s) towards teachers. These questions will let teachers know that there are potentially more students that learn better a certain way. Examples of how teachers could assist students that have specific intelligences could be by playing non-distracting music in the background while students studied or by writing out a problem step-by-step for students. I personally consider myself to be a Bodily-kinesthetic learner as well as a Logical-Mathematical learner because I feel that I can learn best when I am in a lab setting, with hands-on activities and experiments to interact with.

How Should I Teach my Students?

While identifying with the students' multiple intelligences may help, teachers may also have trouble with the way they teach their class and may ask, "How should I teach my students?" Many teachers become teachers because of the ones they have had, and the way their teacher(s) taught them and they may take that method of teaching and replicate it for their own class. However, this method can vary among teachers as each one teaches differently than another, from small changes in the presentation to large differences in methods. My high school chemistry teacher taught me through notes, experiments, and power-points. These types of methods worked for me and many other, and it has been the way I taught through my internships throughout high school. However, while currently in my second semester at Bowling Green State University, I am in an internship at Northview High School and what I have found shocked me. My mentor teacher, Ms. Stewart, taught her students not only by using Modeling Instruction, but also by using ratio proportion instead of dimensional analysis. Her reasoning to why she taught this way was that Modeling Instruction allowed her students to work in groups and more independently, instead of having her stand at the front of the room and lecture at them for the class time. She also explained that using ratio proportion instead of dimensional analysis allowed her students to get a better understanding of what was happening in the problems instead of just

"plugging and chugging" to find the answer, and that it allowed her students to understand the fundamental relationships among items involved in the situation. Ms. Stewart's use of Modeling Instruction amazed me because it showed me that there was not one specific way that you had to teach a class, instead, there were multiple ways to vary in the way a class was taught. This got me to question, "why do some teachers prefer one method of teaching over another?" Ms. Stewart later directed me to a website which encouraged teachers to use Modeling Instruction in their Science, Technology, Engineering, and Mathematics (STEM) classes. This website, the American Modeling Teachers Association (AMTA), works to "provide resources that support the use of Modeling Instruction in physics, chemistry, biology, mathematics and middle school classrooms, and to support and enable collaboration among Modelers. AMTA strives to foster *brilliant teaching* and *deep learning*." AMTA allows opportunities for educators to get professional development and learn how best to teach their students by providing a different approach on teaching than the typical lectures that students sometimes get. The Modeling Instruction also allows students to work more independently and encourages them to ask questions not only to the teacher, but to their peers as well.

Still, even with many innovative and engaging ways to improve teaching in the classroom, it can be hard to get everyone interested. Some people may ask, "*Why* should someone be interested in the same thing?" "Who cares for why the speed of light is faster than the speed of sound, or why a log of wood floats on water while a small rock sinks to the bottom, it just does." "Why should someone learn something that will not affect them in their day-to-day lives?" Nonetheless, there are ways to get students interested. Michael Stevens, during TedxVienna, talked about the importance of questions and why we asked them. Stevens says that he's learned two things from his experiences: 1) people love a good explanation, even those who say they hate learning, 2) anything can be interesting to anyone because everything is related in some way to something they care about. He goes on to explain how people express themselves not only through the clothes they wear and the music they listen to, but also through their knowledge. They share things that reflect onto them and show what they are interested in. Stevens says he learned that you should not be who you think your audience wants you to be, but instead "to say, and make, and show things that allow your audience or your students to be who they want to be." I believe asking students questions about Stevens' suggestions are very important for teachers in connecting with their students and getting students connected to science topics. These questions are the "more beautiful questions" that Berger recommends teachers pose to their students. They will be able to interest their students in topics by connecting it to things that interest them. Harold Edgerton, a former professor of electrical engineering at MIT and receiver of the National Medal of Technology and Innovation, famously said, "the trick to education is to teach in such a way that people only find out they're learning when it's too late." This statement that Edgerton made further supports the fact that connecting with students and finding out how they learn, how to engage them, and how best to teach them can spike their interest to the point where people don't see it as "learning" and become genuinely interested and full of questions about science.

Questions have played an important role in shaping me into the person I am today, an educator, a friend, and a science enthusiast, and I hope that I will continue to ask questions to improve the way I teach, learn, and interact with others. In *A More Beautiful Question*, Warren Berger talks about how Van Phillips managed to change the way prosthetic legs were manufactured by asking simple question as to why the current prosthetics did not work well. This question quickly developed and changed as Van Phillips considered what would happen if he

https://scholarworks.bgsu.edu/writ/vol1/iss1/3
DOI: https://doi.org/10.25035/writ.01.01.03

changed a part or why it was shaped a certain way. Questions can help individuals open their eyes to different perspectives or allow them to go deeper into a subject. For myself, I wanted to find a way so that students would be able to retain information that they learn and remember that the speed of light is faster than the speed of sound. Questions helped me seek a way to improve the way science was taught in schools and to learn how to engage students so they become engaged in lessons and genuinely want to learn.

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