Physics Seminar

April 8, 2019

>>: Can I get everyone's attention? I'm going to have the sign-in sheet floating around for a couple minutes, so just be on the lookout for that.

I want to introduce our speaker today. This is Donna Stokes, one of the professors from the University of Houston. She's made a few visits here to UHCL, but this is her first time in the new STEM building.

>>: Yes, gorgeous.

>>: She was instrumental in a lot of stuff we did, but I don't want to name everything. One thing is some of you may have met her. She was, like, pretty much running the Texas section of the APS meeting. If you guys went to the one at the University of Houston you may have gotten a chance to meet her.

So she does a lot of things in physics, mostly experimental physics. But today she's going to be talking about some things as far as teacher preparation, just another option of interesting things that are going on in terms of what we're doing in physics education. It's a lot different and a lot deeper than what a lot of people may have thought. So I'll turn it over to Donna.

>>: Thank you. So -- no applause needed. So I actually visited the campus about ten years ago or more and gave a talk on some of the condensed matter research that I do, but now I've switched my research focus to look at physics education research and student success in STEM courses and to physics teacher preparation. So that's what I'm going to talk to you about tonight.

Unfortunately they don't have enough ports for me to plug in my changer, so I'm going to be going back and forth peeking around this terminal. So I'll talk about some of the effective components that we have for physics teacher preparation. So many of you may not be thinking about whether you would like to be a physics teacher but we like to tell our undergraduates and graduate students that it is an alternate career path for students with a physics degree and it can be a very rewarding one.

I want to give you a little bit of background about what we do. So all across the nation, there are issues with putting qualified teachers that teach STEM in the classroom in the K through 12 classroom but mostly at the high school level so that we can prepare our students for moving on to college.

So teacher attrition in these areas is pretty low, and that's what I'm going to look at and give you an overview of. What is the teacher attrition as it relates to physics and STEM in general? Then the teacher preparation program we have at University of Houston for

preparing STEM teachers, and this is the program that our physics majors go through if they want to become a STEM teacher.

Also I'm going to give you a little bit of information about how we are approaching teaching physics to teacher educators and we use an inquiry method. And some of you may be familiar with this and some may not, but I'll give you a little background about that. And I'll talk about a physics by inquiry course that we developed to particularly prepare our physics majors who want to be teachers, but in addition to prepare other teachers who may not have a teacher certification in physics but who are oftentimes assigned to teach physics courses.

So many of you may have taken a physics course in high school and how many of you think your teacher was certified to teach physics? Very good. But there were a lot of hands down. So that means you either had a physics teacher that wasn't so great or it was the coach or the biology teacher. So they really weren't certified to teach physics, but nonetheless they were assigned to do so because they needed a warm body in the classroom to do that.

And so the biggest thing I'll talk about is the impact of what we've done with our physics education program for teachers and how it's impacted their career paths as preservice teachers and some outcomes of what we have.

So teacher attrition. Teaching is becoming a career of movement. In and out, and out may be permanent. So we have this issue where teachers are trained. They move into the school districts, but oftentimes they only last two years. If they last five, really good. So teachers are moving out.

But other things that we see is we have teachers who have been in the classrooms for a long time. They're retiring earlier. And then we have teachers just leaving the profession altogether because it's either not fulfilling or they find other employment that's more rewarding.

So how do we deal with this attrition, keeping teachers in the classroom, recruiting them, preparing them, and retaining them? What do we need to do to create a strong pipeline for keeping teachers in the STEM classroom?

So in urban centers like Houston, we lose about 50 to 70 percent of beginning teachers in the first four to six years. That's a lot of teachers that leave just between the first five years or so. As I said, Baby Boomer teachers, teachers born in the 40s to 60s, those teachers aren't staying in the classroom as long. They're retiring after about 20, 25 years.

One-third of those teachers that remain in the workforce that are there now plan to leave for whatever reason. And this is a big cost to us as a nation and to the state of Texas. So with teachers moving in and out, it costs about $2.2 billion per year. And in Texas, we're a pretty big state, of course we have to do everything big, about 800 million of that is lost in Texas. So we really have to think about how to train our teachers so that they will remain in the classroom, and we need to make sure we're serving them to serve the population that exists in the various states.

So the present day population of Texas is what the U.S. population will resemble in about 2040. So currently we have about 37 percent Hispanic and 45ish percent of white. So that's going to kind of be the representation for the whole nation in about 2040.

So we need to train teachers that look like the people we're going to serve. In the state of Texas, of course, we want to train students in Hispanic backgrounds, African-American backgrounds, some of the underrepresented minorities as well as white. But we want to train them and have them remain in the classroom.

So here are some numbers just comparing Houston and Texas to one another. And this is looking at Houston Independent School District, which is the seventh largest school district in the nation. 80 percent of teachers have five years or less experience. So if you have a little brother, cousin, nephew who's going into the classroom in HISD, it's most likely the teacher they're seeing has less than five years experience. Fifty percent of principals also have less than five years experience.

More than 30 percent of middle school math and science teachers teach out of field. So what we mean by out of field is they're certified to teach in one area but are actually teaching in another. 13 percent of high school math teachers are teaching out of field and 28 percent of physics teachers.

In HISD, 80 percent of the students are minorities and 75 percent are disadvantaged. So we have to look at the demographics, the socioeconomic backgrounds, and many different things of the students to make sure we're preparing teachers who will be prepare those students and who will want to remain in the teaching profession.

So how do we address these attrition rates? Well for physics at least, which is what I'm focusing on, we want to produce more qualified physics teachers. How do we produce more qualified physics teachers? I'll tell you that in just a second.

So nationwide, 47 percent of high school physics teachers have a degree in physics. So that doesn't sound terrible until you compare it to other science disciplines and disciplines such as humanities. So in biology, it's 73 percent and humanities, 80 percent. So we're pretty much way lower than most of the other disciplines in having people who are qualified in the classroom.

So in Texas, about 1600 science teachers are certified each year. Less than 2 percent are certified in physics and math, and only one to 10 percent have science composite certification. So science composite certifications allows a teacher to teach multiple science disciplines. They can teach physics, chemistry, geology, and biology. Somewhere in there. I think I got the geo part right.

So we want to be able to train teachers at least for physics to have either major or minor in physics or to be able to earn that composite certification, which will allow them to teach physics. But that's still not the ideal case when they earn the composite certificate but I'll tell you a little bit about how we address the students that do earn this type of certification.

So how do we meet the needs of the students enrolled in the physics courses, those interested in teaching, and those who don't know they want to teach yet? So a lot of people don't know they want to teach. They earn a bachelor's degrees, they go job hunting, maybe it's not so awesome, and someone approaches them and asks if they want to teach. And I can tell you, there are going to be jobs there for physics teachers and there's going to be a bonus associated with that position when you get hired.

There are a lot of myths out there about physics teachers or teachers in general and what they make, but there's a lot to be learned by the student. So make sure if you're thinking of a physics career, you do your research to find out about things like pay, health care, benefits. Because most of you, if I ask you right now, how much do you think a starting teacher makes -- who can give me a shout out? 45,000. Anybody else? Y'all think that sounds about right? You think lower? In Texas you think it's lower? So guess what? The starting teacher in Texas makes about $55,000.

Guess what? How many months do teachers work? Six? Eight? They work all the months except the summer months. They're nine month employees, so, they make $55,000 for nine months, which means they can do additional things during the summer or get an additional job or they can do nothing.

So that's a big myth. One gentleman said it was below 45,000. Wow. That's pretty low. Now, some states, it is low. But in Texas, about $55,000.

So when you look at that and the benefits they offer for retirement, it actually compares very well to what a person who's in research at Boeing at an entry-level position would make because the TRS system, the Texas Retirement System, is pretty good. You usually retire with about 80 percent of your salary if you are vested all the way in.

So think about teaching as a career. It's not as bad as people say and then you get your cool summers off -- well, hot summers in Houston. And if you have a family, that's really, really important when you have a family because you'll have that free time to spend with your family.

So our solution to kind of increase the number of qualified physics teachers in the classroom is our teachHouston program. So the teachHouston program is a collaboration between the College of Natural Science and Mathematics and the College of Education and all the STEM departments are included in the College of Natural Science and Mathematics, and faculty, master teachers, and mentors from the local school districts.

And it's a program that's in place to address the shortage of math and science teachers. So, it's a STEM teacher preparation program. So the students coming into this program earn a major degree in whichever STEM field they wish to -- physics, chemistry, math, computer science -- but at the same time they earn their teaching certification.

But the difference in the teachHouston program and the Department of Education is the teachers who are teaching in the teachHouston program, the majority have taught in the high school for five to ten years. They've taught STEM courses, so, they've all taught physics, math, chemistry, whatever. And they have served as mentors to teachers and

work really well with the administration and the school districts. So the teachers there have the inside scoop on how to teach science to students.

The students, when you get your degree you earn a teachHouston minor, and you can complete this in four years. That's huge. So you earn your physics degree, which a lot of people can't complete in four years, but in this case you can complete your physics degree, your teacher certification all in four years. And we have some unique ways to do that.

So the program uses research based approaches to teaching, and we use inquiry-based learning. Most of the course work is set up around inquiry-based learning. Other things, project based learning and early, intensive field experience. So getting people out into the field as soon as they think they want to be a teacher. Give them that experience early on.

Some other benefits, we have several grants from the National Science Foundation that offer internships, scholarships, professional development, and formal and informal learning opportunities, usually through participation with STEM student camps.

So the teachHouston program is a replication site of the UTeach program which was started at the University of Texas. So they developed this idea of putting the STEM teacher aspect in the STEM college versus the College of Education. And they developed pretty much a whole program around it. They developed the courses and how you should take these courses and several universities across the U.S. have adopted their model to set up their STEM teacher preparation program.

Okay. So as I said, ours is really geared towards this inquiry-based learning and the learning field experience.

So, in 2009, we developed -- the physics department developed a strong collaboration with teachHouston. So teachHouston was there and there was the training of students from any STEM department. However you really need a strong collaboration between departments and teachHouston to make sure your students can successfully complete the program, especially with the program being a four year program.

So we developed degree plans for physics majors and minors to make sure they would be able to complete the program. And the way we did that is we allowed some of the teacher certification courses to serve as advanced physics electives. This helps the student to be able to complete the program within four years.

So this is what the degree plan looks like. The courses in red are the teacher preparation courses. They do their student teaching at the end. But the two key courses are the step one and step two courses. So the reason I like these two courses, they're very important, is they offer early field experience to any student who wants to be a teacher or thinks they want to be a teacher.

So what you can do is you take one of these courses. We call it a tryout course. In that first course you get experience in the classroom. So if you go and teach in the classroom

your first semester and you realize, I don't like little kids, this is horrible. Then we've saved you some trouble.

Because oftentimes a lot of programs leave the teaching experience to the end. You do your teaching out in the field in your last semester and then you get to the last semester and you realize, I hate little kids. I don't want to do this. So this program allows you to get the feel for it, decide if you want to do it. And then if you don't, then you haven't lost very much. You've just lost maybe one credit hour at the beginning of your career.

So also, in 2012, the physics department and -- well, myself and another faculty from teachHouston received a Noyce Grant from the National Science foundation and the Noyce Grant supplies scholarships to students who want to be STEM teachers. So for us, we were -- our program focused on training physics and chemistry teachers. And it offered internships through summer camp experience, it offered the scholarship itself, it offered mentor and advising through both physics and teachHouston. The one thing that came out of this grant was we developed the physics by inquiry course for any student in teachHouston to participate in.

So one thing about this program, though, the scholarships are huge -- $6,000 a semester. But for each year you accept the scholarship, you have to sign a contract to commit to teach for two years in a high needs school district. That's pretty much any school district in the Houston area.

So this way, we can create a pathway for people to get into the schools and hopefully stay in the schools. We also offer them support after they're in the school after they graduate. So this physics by inquiry course is one of our big things that we developed, and I'll tell you a little bit more about this.

So as I said, this was modeled after the UTeach program. So the courses that are in the box that's orange are the prescribed courses that that program suggests. So we offer those courses and in addition, we offer some other courses, the physics by inquiry course and two other courses that were developed after we had such good success with the physics by inquiry course.

So again as you see, you take the two introductory courses that get you experience in the field early on, and then you take a series of courses which will introduce you to curriculum development, pedagogy, and theories behind teaching and learning.

So why do we use this inquiry method? The research shows that learning is deep rooted in experiences. Knowledge arises through the process of inquiry. Inquiry occurs with a community of learners.

So how many of you have had a course where you were taught through inquiry? One. Two. Three. So that's -- this is a nice little crowd and only three people have been exposed to inquiry-based teaching. And I'll tell you a little bit more about it and why we are using it.

Another researcher says students learn scientific methods through inquiry. Students should learn science similar to the way scientists conduct their research. And (inaudible) said inquiry teaching methods correlate with how well students learn STEM content.

So the inquiry method of teaching and learning has been vetted very well through research and has been proven to be a viable method for helping students to learn STEM content even better than traditional methods. However you, as you saw around this room, not many of you have been exposed to inquiry-based teaching and learning. So why is that the case? So inquiry has been around for decades, as I said. Teaching science through inquiry has been recommended by many researches at various institutions -- National Academy of Sciences, National Research Council. They all recommend that science should be taught through inquiry methods.

It's an excellent choice for teaching science. We think it's an excellent choice for preparing preservice teachers. Why do you think that's the case? That's not a science class, so to speak. It's a science class geared to prepare teachers. What would be the importance of making sure we include inquiry in those classes? Any thoughts or ideas on that?

>>: (inaudible).

>>: Yeah, this is all proposed by physics education research. Inquiry is only one of the methods. They have some other interactive type methods that they also propose. But yes, this is one of the methods suggested by physics education research as being an effective method for teaching STEM courses, physics courses in particular.

There you go.

So physics education research says it improves student learning gains over traditional style teaching and is key to promoting success in physics. So traditional style teaching is what I'm doing up here, just lecturing to you, telling you what the concepts are.

Inquiry is very different. You learn through hands-on experiences. So rather than me tell you what the concepts are, I would give you some experiment that you could conduct with some open-ended series of questions that would allow you to use your critical thinking skills to delve out what the concepts would be related to the experiment. So you have no idea what the concepts are before jumping in to some hands-on experiments. And it's really, really fun. It can be hectic, too.

So, if this is so great and so good and recommended by everybody, why is it that the majority of teachers fail to employ inquiry methods in their classroom?

>>: They haven't experienced them a lot?

>>: They haven't experienced them a lot. They weren't taught that way. They were not taught that way. And it's more difficult than standard lectures. I have a past student of mine here and she is a high school teacher so she can attest to how much work it takes to prepare to teach inquiry. It does take a little bit of extra work on the teacher's part so that might deter teachers from doing it.

So we see teachers tend to teach as they were taught. As you say, they have never seen it. Most of you have never seen it. So why would I teach that way if I've never done -- you know, I haven't learned that way?

If teachers are willing to reculture these kinds of classrooms, the first obstacle is the influence of their own personal story. So my personal story is going to guide what I would do in the classroom. Same for any student or preservice teacher who is going to go in the classroom. They're going to use their own experiences to guide what they would do. So if they have not been taught by inquiry, why in the world would they go out and try to teach their students by inquiry?

So we developed the physics by inquiry course, take away the traditional stand in front of the classroom guy and move him to something that's more student centered, students getting involved, putting their hands on equipment and using their critical thinking skills to figure out how this the relates to physics concepts.

So the physics by inquiry encompasses quite a bit. Not only does it have the content knowledge, our course is designed to be the second part of the algebra based introductory physics course. The reason it's not at the level of calculus is because all of these students are STEM majors already. Part of their STEM degree requirement is for them to take the physics course that is calculus based. So we're not trying to reteach them or teach them physics initially. What we're doing is teaching them how to teach physics using inquiry. So we're teaching it at a little bit of a lower level, but it's the same concepts.

It also helped them to develop curriculum for those classrooms. So this will build the personal history within the teachers themselves so they would want to use physics by inquiry style in their classrooms. And this can be done not just for physics, but it can be done for biology, chemistry or any course.

So our motivation was to increase the number of qualified physics teachers produced at University of Houston. So for about the decade before the collaboration started between physics and teachHouston, we had not produced one certified physics teacher. Not one. Not the College of Education nor teachHouston nor the Department of Physics. None of us.

So we were on a mission. We need to change this. If we're going to want to get better students into our higher education physics classes, we need to put qualified physics teachers in the secondary classrooms because better teachers in that classrooms sends us better prepared students. And I'm sure you've all heard your professors here saying oh, my gosh, these students, they don't know this or that. But we want that to not ever be said. We want the students to come to us well prepared.

So, increasing the physics content level for these teachers who will get certified either in physics or get the composite certification is key. Like I say, this will help put people in the classroom who are very qualified.

Also, as we know, a lot of teachers are teaching out of field. We offer this to anybody who's in the teachHouston program. So whether you're a biology major, geo major, anybody can take the physics by inquiry course. For us, this is a plus. They're learning

the content by inquiry and when they're assigned to teach physics out of their field, they're bettered prepared to teach that course.

So who takes the course? All of the students have to be in the teachHouston program. So you sign up for the teachHouston program -- like I said, you just take that intro course and you're in. So there are physics majors, minors, any teachHouston student who wants to strengthen their physics knowledge and this helps for those who will be assigned to teach out of their field.

Non-teachHouston students have also been allowed to take the course. So we've allowed some students who are in our honors biochemistry society -- I think that's what it's called -- to take the course in place of our second half of the introductory physics course. So you might say this is not the same course. It isn't.

However, we have two tracks for the course. The course is taught one course, one classroom. But the students who are honors biology, they have a different curriculum. They do the same inquiry-based lessons and experiments but instead of doing the pedagogy assignments, they do critical thinking and critical skills problems, the typical problems you would do in a regular classroom. The ones in teachHouston, they do some of those problems, as well, but also curriculum development and pedagogy.

So the big thing about this class is when students come out of this class they leave with already planned inquiry-based lessons they can take into their classrooms. That's huge. We just talked about how much time it takes. Not only do you need to have a strong knowledge of the physics but you also need to have the time to create all of this content that is now hands-on, not out of a book sometimes, to match the needs of your students.

So a quick description of the course. We now offer the course in the fall and spring semesters. It can be used as credit toward the B.S or B.A. physics degree or the minor as an advanced elective. This was really huge. Getting physics faculty to agree with this was a challenge, but nonetheless, they did.

But this is what makes the program attractive to students. If students have to create an additional 20 something hours because they have to fulfill all the credits required for physics and teachHouston, then students are going to be deterred from wanting to do that.

So we have it where these credits can be serving teachHouston as well as physics. The course is based off of McDermott's Physics by Inquiry and if any of you have had a physics by inquiry course, you've probably seen that textbook, it's like the bible for inquiry courses. we use PhET simulations, engineering design, and we also have some resources we've developed ourselves. Have any of you used PhET simulations in your classes? Those are awesome.

Now inquiry can come in a couple of different stages. So it can be confirmation all the way down to open inquiry. So we generally operate between the confirmational to guided inquiry stage. The open inquiry is like giving a student a project at the beginning of the semester to work on. They have the whole semester and usually work in groups. You don't really give them guidance but you give them resources to do it. They have to use critical thinking and activities to figure out how to build something that they're going

to use to describe and solve the problem that they have. That's not what most high school physics teachers would do. That's too open ended for them.

They usually will fall around the structured inquiry where students are given an open-ended question and a method to find the solution using their knowledge and scientific evidence to support their conclusion. So they're also given resources to do that, some type of equipment usually is put in front of them.

So if you were to become a teacher and you wanted to use inquiry, you could think about what level of inquiry you would like to have for your students. And you would base that on the students in your classroom.

So inquiry practices are things that we use to take out or carry out our inquiry-based teaching and learning. We use project based learning where they do projects related to real world situations, case studies, engage students in real world examples where they work in groups. And the instructor, instead of teaching or doing anything just facilitates, walks around, talks to the students, asks questions to guide students to solutions rather than just telling them.

Then there are meta question questions and field experience. Field experiences are huge. Getting out in the classroom, getting that exposure to what you do in a classroom, that's really important.

So for us we had several research questions we wanted to look at when we put this course in place. How does learning through inquiry impact preservice teacher's perception of inquiry-based learning? So how do they feel about this inquiry-based learning? Is it something that they feel is worth moving forward with?

How does learning science content through inquiry impact the attitudes that preservice teachers have towards teaching through inquiry? Are student teachers more apt to employ inquiry-based learning subsequent to learning science as inquiry? And what are some of the road blocks student teachers encounter out in the field in the classroom?

So we use pre- and post-surveys, interviews, and we collected from quite a few subjects to get our results here. The results I'll present to you are from three teachers and then general overlook at results from the whole pool. So three preservice teachers said they were appreciative of the inquiry approach and they credit their science teacher educators for helping them get excited about the inquiry method. So if you don't have a science teacher educator that teaches you by inquiry, then you're not going to get excited about it and most likely you're not going to use that approach in your classroom.

Okay. So this is Katrina, just a pseudonym. She said instructors will guide us, scaffold us, but not tell us the answer. So just imagine -- you are the student learning physics by inquiry and then you're going to take what you've learned and be the teacher who teaches your students -- by inquiry. (laughter) Two of me. That's pretty cool.

Okay. So, there was never direct teaching. She felt there was never direct teaching from the teacher. As I said, in inquiry-based, the teacher serves as a facilitator. They really

don't tell you exactly what anything is. They may lead you by questions. She said she appreciated the approach and would try to mimic it in her own teachings as well.

And then Ryan said, theoretically the words are just words dancing around in your head that may or may not mean something to you. Physics by inquiry, you come to knowledge on your own. It grows to be solid and a part of you. So it helps to solidify the person's content knowledge.

So you can imagine if you're teaching by inquiry, there are going to be lots of questions by students. A ton. So you have to really be confident and strong in your content knowledge to be able to handle all these questions appropriately. I like the last part. Teacher educators put him into a flight zone. I don't know what that means, but it sounds good.

So Ryan said there's something amazing about seeing a student learn through inquiry. It just gives me the chills. He's really excited. It's very freeing, the eureka moment. It lifts you up and you will your whole body come alive. Is physics really that great? That's awesome. It's tingly and you want to learn and teach that way again and again, and you want to keep fanning the flames. So this is a situation where he's had an experience where he's watched the students just grow in the experience or the inquiry methods learning.

Jason said experience needs to come in the front door and theory needs to come through the back door. So that means he liked the physics by inquiry because it allowed the students to do a little hands-on experimentation before they knew about the theory. Theory comes last; experiment comes first. This is what leads to innovation. This is how things are discovered and found in the world today.

So just some results from our interviews and our surveys that are related to things that emerged from the five questions, I think, that we asked. So how does learning through inquiry impact the preservice teachers' conception of inquiry-based learning? So one of the key things we found to emerge from most of the surveys was it improved their confidence, that is huge for a teacher and huge for teacher attrition.

If teachers can go in the classroom and be confident about what their teaching and help their students to be successful, they're more likely to stay in the classroom. If you're going into the classroom and you're fighting your students every day and they're not learning, you're going to be very depressed and not want to be in that situation for long.

How does learning science content through inquiry impact the attitudes that preservice teachers have about teaching through inquiry? Changed my belief in method. Worked for me as a student. So if it worked for them as a student in the classroom learning in the physics by inquiry room, then more than likely they'll go out into the classroom and use it.

Truly understood the content, understand better how this may work in a classroom. So it kind of takes away the fear of, "Can I do this? Should I try this?" for the preservice teacher. So all of those are great.

And one comment that we had that supports this, it says this is the only course in which I experienced real inquiry-based instruction rather than occasional lessons in other classrooms. So some teachers may say they're doing inquiry-based learning but usually they're giving you some interactive activity to do, some worksheet to go along with it, or they're giving who knows what but it's not true inquiry. True inquiry will allow the student to explore first and kind of delve out what the concepts are related to that exploration.

A second support for that, this was the first time during my teacher training that I was put in the seat of one of my pupils. So now you're in the seat of the pupil where you're learning by inquiry experiencing the struggles they may face.

So, inquiry-based education is not this easy straightforward thing. That's why I say teachers have to be strong in the content knowledge because you're going to get an array of questions, a lot of misconceptions, and some that are on target. So you need to know what's going on with the content.

This granted me an excellent view into the mindset of a student of science ,working hard and often failing to tease apart the complexities of a concept. This has helped me to empathize with students and to encourage them during the process of learning in a meaningful and personal way. So you don't understand what the student is going through until you've been in the student's shoes.

You can think of yourselves as students in your classrooms. I'm sure you've been frustrated at some point. So you should ask the professor to come sit in your chair, mimic what you're doing and see how they feel. But oftentimes as teachers we don't think of that, especially in higher education. Most faculty in the STEM fields teach by traditional teaching.

I, too, teach not so much by tradition. I don't teach inquiry class. I do teach by including interactive activities throughout the course and questions on concepts throughout the course to kind of keep it from being so boring. But a lot of people don't do that. So it would be great if more higher education professors would pick up on some of this.

Now, University of Houston does offer an inquiry-based physics course and we offered for the algebra based and calculus based but we can only serve about 72 students, and it's a different style. It has the round styles and we have screens all around the room and professors are really there to facilitate. And we have about four undergrad and graduate TAs who also assist with that.

So if more universities could do that, if we could offer more courses like that, I think we would benefits students in higher education in a better way, as well. We don't have a problem with attrition, though. Teachers in higher ed don't go anywhere. We stay till we die.

Are student teachers more apt to use employ inquiry-based learning subsequent to learning science by inquiry? Of course. Those who took the course created more inquiry-based lessons and expressed they would employ it in their classroom. Teach as you were taught.

What are some of the roadblocks student teachers encountered? So these were numerous. So just imagine the hands in the room, not many of them went up when I said who was taught by inquiry. So imagine yourself going out into the classroom to teach by inquiry in a school where the teachers are much older than you are. So much older than you are most likely were not taught using inquiry.

So if you're not a leader already thoughts in that school, which you're probably not if you're a first or second year teacher, then you walk into a set of people who already have a mindset that we teach this way and you're going to be the young person to tell us we need to teach this way? That's not going to happen.

So there's a lot of issues with being able to maneuver through the other teachers in your discipline, who typically you share -- how do you say it, Carol? You're, like, the team leader? The department leader. So the departments teach a particular curriculum for the course. So if you go in there and try to tell the folks who have been doing it for 20 odd years that now you want to do it this way, that's usually not the case.

But there are ways around that and we have a huge mentoring program for our students so we can help them maneuver those obstacles. One of the ways we teach them to maneuver this is if you're in a group where they're not making changes, try to introduce one thing, you know, maybe a semester and invite the teachers to come in and observe your classroom and what you do and see if you can sell them on what you're doing in your classroom. And students have had a lot of success with that.

Time -- again, our physics by inquiry course allows you to develop curriculum for your classroom while you're in the class. So you don't have to go out and recreate a whole set of lessons. We also offer professional development opportunities where you can take what we call cookbook style lessons and convert them to inquiry style lessons. So we give the students ample opportunity to make and develop curriculum before they get into the classroom.

Dragons in the backyard. So when you walk in the school and there's a dragon in your backyard, you had better prepare. The dragon, of course, is the accountability of the system. So we know about this testing stuff and if I'm teaching by inquiry, I need to make sure my students will still be able to pass the test. So that's a big dragon in the backyard that hinders a lot of students from even trying this.

They have that pressure in the administration to make sure the students are successful on all of these assessments. So they sometimes may abandon using the inquiry-based method to make sure they meet these accountability systems that have been set up for them.

So to support that, one student said inquiry-based teaching is on my campus considered at best novelty and at worst a myth. Wow. And so I have struggled to weave my own methods through the fabric of the pre-existing status quo. So students are trying to figure out how to maneuver this. But I have to say these students manage to work around it and in the mentoring, we help them to get past these obstacles.

So what has been the impact of the physics by inquiry course? Based on our surveys and results from our interviews, we see that it has improved the students -- the preservice teacher's self-efficacy and confidence. They are more confident going into the classroom because they have a stronger content knowledge and then they have this self-efficacy knowing that they can go in and control their classroom and teach them physics or chemistry or biology by inquiry.

As I said, we give them many ways to develop pedagogy for their classroom through professional development, the cookbook lessons turned to inquiry, and we support them and discuss how they can get around the barriers. Barriers are not just with teachers and administration. You can also have barriers of students.

Students haven't been taught by inquiry, either. So they're coming into a science classroom that's already hard. And then you also want them to learn it in a way that they've never seen before? So you really have to be able to manage your classrooms and help them understand how they method is going to be better and beneficial for them.

It allows preservice teachers to experience the process of inquiry learning. As I said, you'll teach the way you learn. Learn science as a scientist, and it changes the mental model of the classroom prior to student teaching. Remember, student teaching doesn't occur until your last semester. So this helps to prepare you of what you want the classroom to look like before you get out into the field.

So we are hopeful and so far have been very successful as all of the students who have graduated with the physics certification are still teaching. We hope that something like this in programs for teacher educators will help to improve attrition rates.

So some of the key outcomes, remember I said we had graduated 0? So since 2014, we've since graduated 11 physics teachers. And you may say, 11 teachers? That's nothing. That is huge. UH Clear Lake, how many have y'all graduated? (laughter) But that's -- we laugh at that, but if you go around, and you can go to very large institutions to very small institutions, and you'll find out that very many of them are not graduating very many physics teachers at all.

So there are a lot of different efforts that have been put in place. One in particular is the Physics Teacher Education Coalition, by the American Physical Society. This coalition is designed to specifically increase the number of qualified physics teachers in the classroom, and they bring together physics faculty from around the country.

So it's not education folks. We're not depending on the colleges of education to train the physics teachers. We've realized that if this is important to us, this is something that the physics faculty and physics departments need to take as their own burden.

So it brings together faculty from around the nation. We share ideas, best practices in the field and, try to help one another build programs at our institutions that will produce physics teachers.

So as I said, all of them are still teaching and they're in the Houston area. That physics by inquiry course is open to not just the teachHouston but also the honors biology, has

served 115 students, and that number should increase because I don't think it includes the spring 2019 enrollment.

One of the things we're really excited about is because of the success of this course, we created two similar courses, one for biology biochemistry and a physics for the middle school level. This one is taught through teachHouston and the College of Education. The biology, biochemistry is teachHouston.

So this is one of our alums. He's a teaches at Spring Branch ISD. He says that. But -- (laughter) he talks about physics and how great it is. And then this is another alumni. He is a math major with a physics minor but guesses what he's teaching? Physics. He was hired to teach physics. He's also one of the local teachers of the year. We're very proud of that. He runs a -- what's the name of it? It's like a fab lab? But it's not a fab lab. Maker space. He runs a maker space program every year. He's at Clements, I think? So doing wonderful things. Wonderful things.

So I'm just going to end. I know y'all are tired and ready to go home. Hopefully if we have Wi-Fi, we can show a little clip of the course. What is all of this? Do I want to enable that? Nope. And I don't know if you'll hear it. No? Let's see. Because, yeah, this volume is up.

>>: Try it now.

>>: It's already playing. Yeah, it's not -- no sound. So you can watch it and imagine what they're saying. But basically, we're talking about, you know --

>>: If you'd like to send me a link --

>>: Sure I can do that. Students are giving their account. I'll let it play through. This is one of our master teachers. She taught in the school district for 17 years and came back and got her Ph.D. and she teaches the physics by inquiry courses.

So you've got to hear it. It's just no fun to watch. They're saying some really good stuff. The first student they showed there, he said -- he had no idea what was going on in this class but it turned out to be one of the best classes he had.

And then there's another student who said -- oh, my gosh, where is she? Yeah, she was talking about, I didn't have any idea how I was going to pass this physics course. She was a biology major. She was, like, this physics by inquiry stuff was really sounding scary to me but she ended up really liking it.

So that's no fun to watch. I'll stop there. I'll just stop it there.

So that's it. I hope I've inspired you to at least think about a career as a teacher. If not, just make sure you tell your friends who are in physics. If they're not sure what they're career choice is going to be, that they could consider teaching.

Right now at University of Houston, we have some pathways to earn a teaching degree. For instance, if you're about to graduate, you didn't know about these teaching programs,

we have a program that offers scholarships that will allow you to get your teaching certification in one and a half years.

We also have a masters program but the masters program is for people who are already teaching in the field where they can come back and earn their masters in about one and a half years. And it's all supported. I'm talking good money. That $6,000 a semester is real. Yes.

So if you have any ideas and think about that and want to have more information, just contact me at University of Houston, and I thank y'all for being patient with us.

(Applause.)

Any questions? I know this is different from the science talks you hear all the time. So anything?

>>: What kind of classroom do you teach the inquiry-based learning in?

>>: So it's not a total scaleup style classroom, as it was developed by (inaudible) and crew. It's a classroom that seats 72 people. And we have about ten, 12 round tables that have outlets in the middle where you can plug in your computer. We also have space on the tables to set up equipment. So the students work in small groups.

Around the room there are screens so that if a teacher is putting up something, it will get projected all around the room. And then we have about four to five graduate or undergraduate TAs and the professor who just stroll around the room. And stroll around the room, listen to the conversations.

Now, the students are given handouts to help to guide them. Remember, the inquiry can be various levels. So we give them mostly structured inquiry-based worksheets. We also take some time to let them do problem solving. We know if they're going to pass a test, they need to have problem-solving skills. So we also work some of that in.

But something that U of H has done in the past, I want to say three or four years, maybe about five, is offering recitation sections to the students in the introductory algebra courses. So they're run similar to the inquiry-based classrooms where the students come in. Actually they're run by undergrad teaching assistants and they come in and work with them with problem solving or concepts they may not have understood during the actual class time.

>>: So on your slide with roadblocks, I noticed you had one on there, materials (inaudible).

>>: Yes.

>>: I'm curious, I know a lot of school districts in this area don't even have enough money for students to have books. How much more expensive is it to teach inquiry-based courses where you need additional equipment for hands-on experiments and things like that?

>>: Very good. So the question was, there was a point on the slide about materials as being a roadblock and oftentimes school districts don't have much money or even money for books. Oftentimes we will loan out equipment. But we've taught the students to use things you can find around the house for experiments.

So we have some high-tech ones where you may need a force probe or something like that. We have equipment that students who come through our program can borrow. We may not have enough for ten in the classroom, but to have five groups in their classroom. So they can borrow equipment from the University of Houston through the teachHouston program.

But we also equip our students with ways of finding grant money. So we've kind of honed in on how to find grant money for our students. We want to let them know there are ways for them to get grant money. We had a student to graduate, in her first six months she had already acquired a grant for her classroom. We try to equip the students so they know where to look. That is actually a part of their professional development is a grant writing course. It's not a full course, but at least some introduction to how to get that.

But we tell students to work with what they have. There are lots of lessons out there and they can also take a cookbook style lesson and transform it into an inquiry style lesson. Usually if they're using cookbook style, they already have some type of equipment available to them. So they can change that lesson based on what they already have.

But for students who are in poorer school districts where they cannot buy anything, you have to be creative. You do not have to have actual equipment in front of them. That's what those PhET simulations are for. You can build an inquiry lesson around a PhET simulation. Even if every student does not have a computer, you can have one computer and project that computer. So those are some ways to get around that.

>>: (Inaudible).

>>: Oh, yeah. Over 20 years.

>>: (inaudible) pushing it now?

>>: So the question is this has been around for a long time. Why are people pushing this type of learning now? Anybody want a take a stab at that? Yes?

>>: You're dealing with students (inaudible) the traditional methods of teaching (inaudible).

>>: Yes. Anybody want to add to that? You want to add to your own -- answer my own question. I love it.

>>: (inaudible).

>>: Yeah, so that helps to have that hands-on stuff in front of you to touch where you can no longer be lazy. You can't Google it. But if you think about how the U.S. is ranked in terms of math and science -- year, yeah, we're just going to do this. We're the

worst. We're not up there. So researchers are trying to find ways to engage millennials. Y'all don't learn the same way I learned. I did okay with the traditional style teaching. Did okay. Wasn't too bored by it.

But because you have so many things like computers, cell phones, where you can Google everything -- we think we can find the answer to everything by just Googling it -- you're not engaged in the learning process. So this is why I think a lot of higher education lose faculty, as well. If we continue to teach in a traditional style, students are really disengaged rather than engaged.

So we have to do something to get students to be more engaged and this inquiry, interactive type teaching is now, like you say, the big push of all researchers across the nation. And not just in physics. This is in just about every discipline now.

>>: (inaudible).

>>: So that's the old schoolers, and I guess I'm the old schooler now. Maybe I'm not quite. Let's say a few years older than I am. Those people still feel that I need to go in the classroom with a book and a piece of chalk. Literally, chalk. Not a marker. Chalk. So you know how old school that is.

And they feel like I learned this way, why should I change the way I teach? These students should be able to learn the same way. But students are not programmed the same way they were. So we have to make the adjustments. If we don't make the adjustments, we're going to remain at the bottom in a lot of these areas.

>>: Also I think for physics in particular there's probably a lot more pressure because it seemed like when I was in school, you know, the idea of, you know, (inaudible) 20 percent of students (inaudible) was considered acceptable. And nowadays, that just doesn't fly. So I think in physics, you know, you have to -- students need to learn it actually now. You can't just teach it and well, if they don't pass --

>>: So, yeah, when I took physics and you sat in a classroom, depends on the professor, they might come in and say look to your right, look to your left -- one of y'all not going to finish this class. (laughter) 50 percent of y'all are going to come out of here. You need to get used to it. I don't know if that's going to be you or your neighbor who's going to make it.

So there's pressure from upper administrations at least in higher education to make sure that students are successful in their introductory classes, and usually those classes are huge. At U of H we have about 250 kids in each lecture. So that's a lot of people to try to reach out and touch. So you need to tailor your teaching styles.

But what's important is to do that before they get to college. We want them to be exposed to this earlier on while they're in high school so that when they come to us, they're ready to go. They're engaged, they're ready to learn, and they want to do the interactive activities.

We get a lot of pushback from the students in the class. We advertise it, we tell them specifically that this is the type of course that it is. The course is a three hour long course but what students do is say, oh, three hour course, I'm going to take that one and be done with it but they don't read the description. So then they come into the classroom and are, like, what is this? I didn't sign up for this. Actually, you did.

And then they get in there and they can't keep their phones off. It's very hard to teach students for three hours without totally losing them. So you have to have activities that engage them, that make them think, so that by the time they get engaged in the work, they lose track of time. So we still get, you know, quite a bit of evaluation comments that say I don't like this class and I didn't know I was signing up for this class and this is the worst way to teach but then we get the ones that say I love this, this was better than any lecture I could have sat in write probably would have been sleeping.

>>: (inaudible) there's a big gap (inaudible) there's a big gap between that technology and the knowledge (inaudible) with how to blend both together and interact them.

>>: That's right.

>>: (inaudible) that interaction. All these computers -- (inaudible) I mean, you name it. Everything is (inaudible) but then you've got this other side.

>>: With the knowledge behind it.

>>: The books are there, (inaudible) can use imagination to (inaudible) where everybody is.

>>: So how do we bridge the gap, basically? How do we bridge the gap between the technology and what students are used to having and the actual knowledge behind this? So I've had students say to me I'll never use this when I get my job. Why do I have to learn about incline planes? It's not about using that. It's about how to solve problems.

If you don't know how to solve problems and think, you cannot have innovation. Nothing new will come. But you have to have that background knowledge to be able to move forward into this technology world. How does your cell phone work? You go out there and ask, and people don't know. So we need to help people understand the knowledge behind all the things that they're using today so they can think about things in the future. How can you think about the future if you don't know how this works?

>>: You've been mentioning about high school teachers but how are you integrating (inaudible) or junior high? Because I feel like it's harder for a high school student grasp this kind of learning because (inaudible) start from the bottom up it's going to be a lot easier for them to understand and build on (inaudible).

>>: So very good question. Her question was you're talking about all of this and inquiry for the high school level but what about starting at the younger age to help to build this up? That would be wonderful if we could do that. We're struggling to get it at the high school age. So we can start at the high school age. We're hoping that that will at least transfer into the higher education.

At the younger ages, they actually -- kids at that age love to explore. At the middle -- love to explore. But at those ages they have to learn a whole lot of stuff and you remember those are the building blocks, when you start. So there are a lot of different schools that actually teach kids that way. Actually my kids went to a daycare that was like that. They didn't teach them, you know, take the paper home and write an A. They taught them in different ways so they could explore. But that's not something that's commonplace. We kind of leave these younger years for the students to be taught kind of traditionally.

But I agree with you. I think that's a place we should start, because how many of you tinkered when you were little? You loved to build and stack things and figure out how it was going to fall apart and then by the time you got to high school you were, like, what? Some of you may have continued but the majority of people lose that interest. And what we're trying to do is keep that interest. Right now we're trying to get it into the high school. Very good question and observation.

>>: Yeah, I was thinking about (inaudible) you're right, it's like they're kind of taught like that at the early ages and then some transition into this whole lecture environment (inaudible).

>>: Back, right.

>>: And so it's kind of crazy. (inaudible)

>>: It is. It is. Yeah, the 1950s style classroom. It's a challenge. But at least we're trying to make, you know, some efforts through our program to equip the teachers so they can go out and teach the students.

Like I say, we send them out there with the tools. Will they use the tools in the toolbox? We don't know. We're there to help them and mentor them, but we don't have a guarantee that they won't have enough -- you know, too many roadblocks to continue on that pathway. But we hope so.

And I would love to see a lot of this go into the middle school so that other physics course for middle school teachers, it is taught using engineering project based learning so it's all centered around projects and build. So they build bridges and using toothpicks and things like that for the middle school teachers to take into their classrooms.

We have not done anything at the elementary level. The teachHouston program is geared towards seven through 12. The College of Education does the rest. So if it happens, it would probably have to come through the College of Education and that's usually not going to happen because they are general education. So they do have some STEM education specific courses, and they do teach with some hands-on guidance but not as focused as we do for the high school level. Yes.

Thank you all for listening.

(Applause.).

(End of class)

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