

**Student questions: Dr. Fran Bagenal colloquium on “Think Global, Act Local:  
The Demographics of the Space Sciences”**

10/13/21

**Fran responds:** First of all, let me say thank you for inviting me to speak with you at ASU. It was a big disappointment not to be in person – but I hope in the spring we will be traveling again.

Secondly, I need to make it clear that I am not a qualified researcher in education, demographics or sociology. I do not do the research nor can I keep up with the literature. My approach is to look at the materials – mostly from the American Institute of Physics – and come to some conclusions for my self. Mostly, I just want to toss out some ideas to get people thinking. URC=underrepresented communities

Do you or your team know if there are any ongoing research or thoughts on other ways of encouraging more women in STEM such as: STEM curriculum review for high school students.

I am sure there are studies of how STEM curriculum changes at high school could encourage more women and other URC to engage in STEM. But I think it is as much about style and approach as content.

Here’s a National Academy report – a bit heavy!

[https://www.purdue.edu/hhs/hdfs/fii/wp-content/uploads/2015/07/s\\_iafis04c02.pdf](https://www.purdue.edu/hhs/hdfs/fii/wp-content/uploads/2015/07/s_iafis04c02.pdf)

Or a quick Google brings up several studies on how to make STEM more engaging at K-12.

Do you have statistics for the number of female that drop out of college and post graduate programs?

The slides on page 7 & 8 of the slides I presented – see .pdf posted on the class website – show some numbers, but not exactly what you are looking for. I wish someone would make the plot on slide 31 for women and men separately. I’m sure the book Talking About Leaving Revisited has these numbers – but it’s quite a big read! The whole 516 pages are available here:

[https://casa.colorado.edu/~dduncan/wp-content/uploads/2019\\_Book\\_TalkingAboutLeavingRevisited.pdf](https://casa.colorado.edu/~dduncan/wp-content/uploads/2019_Book_TalkingAboutLeavingRevisited.pdf)

Wouldn't a better metric be the amount of pressure women feel to enter certain fields, rather than # of degrees women get? Number of degrees seems to assume women are exactly equally interested in science naturally. Is there evidence to reinforce that assumption?

This is a debate that has raged for centuries – if not millennia! I would argue that women are just as interested in science as men. The meme that women are not interested in science, that they should not bother with such stuff and just buy fancy clothing ebbs and flows every few years. Is dis/interest in science “natural” or “manipulated” by, say fashion industry or science documentary business.... Good topic for a class debate!

Many of my most intelligent BIPOC friends growing up were pressured by their parents to pursue careers as doctors, nurses, or lawyers. Many cultures see sciences as undesirable. Could this be part of the reason for the discrepancy, or is it just to pressure other cultures to value the same career paths as white Europeans?

Yes, indeed – doctors, nurses and lawyers are seen to be careers that help society (and get well paid). Scientists also get paid well and help society – but that’s not such common knowledge.

You mentioned multiple times that there are plenty of career options for Physics degrees that aren’t academic, but that people don’t about know them. Personally speaking, my sister is in the midst of getting a Biology degree specifically because it’s a clear pathway to becoming a medical Doctor (it’s been her dream seemingly forever). What are the non-academic career options for those with a Physics degree that we need to promote and get high school students excited about?

One of my UG students told me he got into law school without taking any LSATs because they said a physics bachelors was proof he could do well at law school.

There are a bunch of suggestions here

<https://www.aip.org/career-resources> and here

<https://www.spsnational.org/sites/all/careerstoolbox/>

Physics bachelors have the lowest unemployment on graduation, by the way.

A lot of the information was about why STEM degrees locally have extremely low rates of women graduates, but you mentioned at the beginning that countries with low gender equality seem to paradoxically have extremely high rates of women STEM graduates. What are those countries doing right, and is there anything we can learn from their success in this specific area?

I do not have data – but I can speculate. (1) I think that in wealthier, culturally developed countries there is a feeling amongst boys of “why bother” to do all the work to get a STEM degree when you can just have fun – e.g. playing video games. (2) Engineering, law and medicine are generally perceived to be higher-status and better paid – so the guys in developing countries go there and leave science for the women.

I know that some people refer to undergrad classes as "weed out" classes. Wouldn't these sorts of classes be mostly weeding out the women and minorities since these groups already feel somewhat out of place?

This is EXACTLY what Talking About Leaving Revisited is all about. See chapter 7 - [https://casa.colorado.edu/~dduncan/wp-content/uploads/2019\\_Book\\_TalkingAboutLeavingRevisited.pdf](https://casa.colorado.edu/~dduncan/wp-content/uploads/2019_Book_TalkingAboutLeavingRevisited.pdf)

If physics undergraduate research experiences were more available, do you think students would have a better sense of belonging in the field and therefore have more persistence?

Yes! There’s plenty of anecdotal evidence – not sure about rigorous stats. We do indeed need to crank up REU programs – e.g. get NASA to fund such programs for Planetary and Astro students.

There is clearly a negative stigma associated with physics, I don't even like the physics classes I had to take, although they weren't actually bad classes by any standard. Do you think kids should be reached out to earlier to remove negative stigmas about physics?

Absolutely! But I also think Hollywood could do a much, much better job. I mean “Big Bang Theory” – really??!! Bill Nye – I do not know any scientists who where bow ties and a white coat.

I've always felt like you had to be very talented mathematically in order to be successful in physics. Do you feel like accessible career fairs geared towards high schoolers with representation of those with higher education in physics would attract more underrepresented groups, or is it more of a confidence issue, or is there some more impactful way of increasing interest?

We need bridge programs that help students who come from high schools with limited math teaching – or for students who need a second chance with math – to catch up and get the skills – and confidence – to take STEM classes at college.

What is the most challenging aspect in trying to increase diversity in physics and astronomy?

I would say (1) getting education better funded at high school, community colleges, state universities; (2) changing culture – see response a couple Qs up.

What changed after 2009 that caused the number of Latinx/Hispanic PhD degrees to increase so dramatically?

Good question! Funding to Minority Serving Institutions? Some notable role models? A film/TV show that showed Latinx/Hispanic scientist?

Are minority students taught by tenured professors more likely to switch majors/drop out?

I don't think it's whether the professor has tenure or not that matters. It's the quality of their teaching. But I would say that the quality would likely quickly improve if effectiveness of teaching was taken seriously in tenure decisions.

Because markers of excellence in STEM are identified by the majority white male demographic, how could educators be instructed to address their personal bias of what makes a good scientist?

Most universities have bias training programs. Whether white male faculty are persuaded to take them is another matter. I think it would be nice to have some good examples of teaching – say on YouTube – of good STEM classes, say, presented by a range of people.

Do you think “weed out” classes contribute to a culture where women and minorities are discouraged from continuing their undergraduate physics/other stem degrees?

Yes! This is EXACTLY what Talking About Leaving Revisited is all about. See chapter 7 - [https://casa.colorado.edu/~dduncan/wp-content/uploads/2019\\_Book\\_TalkingAboutLeavingRevisited.pdf](https://casa.colorado.edu/~dduncan/wp-content/uploads/2019_Book_TalkingAboutLeavingRevisited.pdf)

As you mentioned, in your mind the biggest issue is with education at the high school level; is there any data available/any studies done tracking stem pathways for high schools in tribal or indigenous communities?

Excellent Q – I wish I knew the answer. Sorry. If you find anything out, please send me an email.

Have any of the recent initiatives for increasing the participation of minoritized communities in STEM (i.e. through AGU etc.) proven effective?

I think it's too early to tell. We need a few more years. Here is a National Academies report on the effectiveness of NASA's outreach programs. Some work, others not so much. NASA has adapted accordingly. Hopefully AGU will do similarly  
<https://www.nap.edu/catalog/25569/nasas-science-activation-program-achievements-and-opportunities>

Are the proposed solutions (i.e. involving students in research) expected to yield an immediate result?

For the specific students involved – I'd say yes. As a program they will take 3-5 years, I'd guess.

Do you think it's possible that the limited number of physics majors will lead to greater job availability which would turn the problem around naturally?

That's wishful thinking, in my opinion. I think there needs to be serious investment in education.

Introductory physics (as I remember it years ago) was a sea of formulas which mostly focused on motion. Do you think it would be beneficial to alter the curriculum to include a breadth of topics that make it sound more diverse than that (i.e. basics of motion, basics of astrophysics, etc.)?

Absolutely! I think there's strong evidence of this – see the Physics Education Research literature <https://journals.aps.org/prper/>

Does supporting citizen science, and getting young “arm chair” physicists more involved, helped with encouraging high school age students?

Yes – and lots of local astronomy clubs are reaching out to high school students to get them involved in projects – or just looking at the sky.

You said you liked looking at the numbers, but what convinced you to continue studying women in physics and other STEM forms?

The numbers looked weird! Kept me looking.

How do you explain the high numbers of women with physics degrees in countries such as Turkey/Albania?

I do not know how to explain it – but I can speculate. (1) I think that in wealthier, culturally developed countries there is a feeling amongst boys of “why bother” to do all the work to get a STEM degree when you can just have fun – e.g. playing video games. (2) Engineering, law and medicine are generally perceived to be higher-status and better paid – so the guys in developing countries go there and leave science for the women.

Chemistry is well known for having very difficult weed out courses (often for those on pre-med track) so why do we not see a big drop off from high school to college in chemistry like we do in physics?

Good question. I do not know the answer. Perhaps people see a career – eg. in medicine – that requires chemistry (but perhaps less need for physics) - ? What do you think?

What is your interpretation on why there are fewer women PIs past the 25-year mark in having a PhD?

This is historical – women growing up in the 50s-70s were strongly discouraged from getting an education.

A few of my friends graduated with Physics bachelor's degrees and then taught high school afterwards. They have all quit teaching since then, stating lack of pay but also lack of student interests. What can be done to not only incentivize pay and support for teachers, but also create an interest among students at the high school level?

We definitely – as a nation – need to invest more in education. Pay the teachers better, give them better training, and provide more support in the classroom.

Could it be that a country like Germany has such a high number of Physics PhDs compared to Physics Bachelors because of the job opportunities available with a bachelor's in physics?

I do not believe the job opportunities in Germany are any different than in the US. I think it's about the education systems. Germany (and other European countries) invest much more than the US in education.

Why would weed out courses be considered the biggest reason to leave physics for women if chemistry also has a lot of weed out courses?

Good question. I do not know the answer. Perhaps people see a career – eg. in medicine – that requires chemistry (but perhaps less need for physics) - ? What do you think?

How does money affect the numbers when looking at if people stay in school or drop out?

Do you mean cost of education? Yes, I think that's a big factor. We need – as a nation – to make education more affordable. Or do you mean job pay? I think scientists get paid much better than people with non-STEM degrees.

What got you interested and involved in this problem?

The numbers looked weird! Kept me looking.

If physical science teachers adapted an easier language for their students the rate of minority students would likely increase; is there any way to implement this the educational system?

If you mean by “easier language” less mathematical, less jargon, translating technical words into everyday language – yes! If you mean thinking about english-as-a-second-language then we need to invest in necessary support.

Many scientific institutions have a history for racism; what do you think is the most effective way of dealing with this issue besides punishment?

There has to be. I think that most places are waking up. But I agree, it has to be positive.

What can students, both undergrad and grad, do to help get science more diverse?

(1) Connect with everyone, all people, and convey your excitement about science. (2) work with organizations to make connections, start mentorship groups, social events around science. Yes, students can make a difference.

Is there anything individuals can do to reduce the imbalance in PI genders or is it more a systemic problem that requires major changes to how science is lead?

We are finding that it is more systemic, more institutional. But there are training programs that individuals can engage with.

Are there any studies looking at STEM degree outcomes for students with serious psychiatric health conditions? If not, is this something you may investigate in the future, to see what impact such conditions have on various demographics and their success in STEM degrees?

I agree this is an important issue. And something I will think about. But currently I do not have the experience or knowledge to address.

What can people do to help increase the data available for studies like the ones you’re involved in?

Spread the word! Talk about it, post about it.

Are there explanations for how Iran has achieved 60% of physics bachelors awarded to women, compared to only 20% in the US?

I do not know how to explain it – but I can speculate. (1) I think that in wealthier, culturally developed countries there is a feeling amongst boys of “why bother” to do all the work to get a STEM degree when you can just have fun – e.g. playing video games. (2) Engineering, law and medicine are generally perceived to be higher-status and better paid – so the guys in developing countries go there and leave science for the women.

Could the drop-off in physics degrees be related to students not being able to visualize future career paths in that field?

I think that is very likely a factor. And academic departments, professional organizations, NASA, etc; need to show that there are multiple career paths with a physics degree.

What can underrepresented-minorities currently in a STEM PhD program do at our institutions to support retention in undergraduates and high school students?

(1) Connect with everyone, all people, and convey your excitement about science. (2) work with organizations to make connections, start mentorship groups, social events around science. Yes, students can make a difference.

Could you share a link (or ideas of your own) on the best interactive teaching practices, especially those that best support physics and astronomy?

see the Physics Education Research literature <https://journals.aps.org/prper/>

The one thing I tell junior faculty to think about while teaching is “Look out at the classroom. Ask yourself, what’s going on in their heads? If you do not know, then ask them”

Given that the most significant drop-off of interest in a physics career occurs between high school and college, what efforts do you think high school teachers or college recruiters could do to spur interest?

Since only 40% of physics classes are taught by someone who has a bachelors in physics, the first thing is to recruit more physics bachelors to teaching, pay them better, and provide the support they need in the classroom.

Do you think that in colleges with a majority population of minority students the trends currently seen in the various plots would be the same (physics bachelor degrees awarded decreasing recently)?

This is a good question. I do not have the data to answer. But it would certainly be worth investigating. I suspect that minority serving institutions (MSIs) do better at graduating URM.

To your knowledge, have there been mass qualitative surveys as to why underrepresented groups drop physics during undergraduate?

Yes this is a major topic in Talking About Leaving Revisited is all about. See chapter 9. [https://casa.colorado.edu/~dduncan/wp-content/uploads/2019\\_Book\\_TalkingAboutLeavingRevisited.pdf](https://casa.colorado.edu/~dduncan/wp-content/uploads/2019_Book_TalkingAboutLeavingRevisited.pdf)

When will the results from the Space Physics diversity survey be released?

The 2011 survey results are here:

<https://deepblue.lib.umich.edu/handle/2027.42/166102>

The next Decadal Survey has only just started so it will be 18 months or so before these data are updated.

The percentage of women between 18 – 45 plot (I think those were the ages), what is the actual reason the US displays a downward trend there?

You can trace this trend back to the percentage of degrees awarded to women over the past years.

Would you say that the “pipeline” is preferentially “less leaky” for women in physics between PhD and professorship?

Yes – I would say that the main leak is undergraduate, with less drop-off later. This is unlike some other areas of science where there are ~50% women at bachelors, little less at PhD, and then steady drop off later in the career. I think that if women survive/make-it as a physicist through PhD then they stick with it!

You mentioned that the leak in the pipeline is most observed in high school students transitioning to college. Do you think its valuable to integrate domestic upbringing and family culture instead of pedagogy and education system?

Yes, bringing parents and family into the fold would be good. It would also help if there’s more financial support for students to take STEM majors at college.

Have efforts been taken so far in trying to motivate graduate students to take up teaching jobs instead research?

There are some. I heard of something at Brigham Young University. U of Colorado has tried in the past too. There needs to be a more systematic approach.

All the women in my life either work in healthcare or education. How do I convince them to change to physics? How should I go about that conversation? Would that be smart to do because I don’t ever want to tell someone what they should strive for in a career? Please help, Thank you!

There is certainly an impression that though education and healthcare people can do good for society. We need to show that physicists also do good for society – e.g. address climate change, develop prosthetic limbs, improve materials that are better for houses, aeroplanes, tools – spacecraft!

As someone who has been a part of challenging "weed out" classes in both high school and undergrad, what do you think are some positive ways we can change curriculum in order to better suit all students involved?

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What measures has the country of Turkey taken to have such a higher percentage of women with STEM bachelors degrees and is there anyway we can implement some of those measures in the US?

I do not know how to explain it – but I can speculate. (1) I think that in wealthier, culturally developed countries there is a feeling amongst boys of “why bother” to do all the work to get a STEM degree when you can just have fun – e.g. playing video games. (2) Engineering, law and medicine are generally perceived to be higher-status and better paid – so the guys in developing countries go there and leave science for the women.



A "stereotype threat" regarding each genders reaction to the statement "this exam will be hard" produced results that women scored lower than men and then both genders scored the same score when told "this exam is designed to be gender neutral". How do you soundly collect data from a test like that- is the same group of men and women utilized in taking both exams with different stereotype threats, do they all have the same background? I personally find it difficult to seek correlation between performing poorly because the exam is hard and performing less-poorly than before because they were told an exam is gender neutral- is the threat "this exam will be hard" not viewed as gender neutral as well?

I am not an expert in this. I suggest you read the paper – here: Miyake, Kost, et al, *Science* Dec 2010

Could it be possible that a major disparity in women and minorities working outside of natural science and engineering faculty positions actually comes from a prejudiced hiring environment? There was an APS infographic recalling a large majority of women students in physics courses through high school but an exponentially smaller percent of women as assistant professors, mayhaps the leaky pipeline is industrially induced rather than personal choice?

I suspect there are multiple factors. Yes, some cultural, some institutional, some being attracted to other careers – and some bias and/or prejudiced hiring. I think we need to work on all fronts.

Do you think a lot of where women and minorites leak out of the pipeline is the the actual or presumed lack of a work life balance in stem fields?

Personally, I do not buy this argument. I think STEM fields are no worse – or better – than other professions. Do lawyers get more time off? Do accountants have a more balanced life?

Has there been a correlations study done about how effective providing suplus funding to women and minorites is?

I do not know of such a study. But I do think it is clear that subsidizing college would good good for everyone.

How much overlap is there between the strategies used to retain women vs. other institutionally oppressed groups in space sciences?

I used to think that women were the “canaries in the mine” – that fixing what puts women off would solve the problems for everyone. But in the past few years I have opened my eyes and seen that this is a simplistic approach. I think there needs to be careful, special attention to needs of other groups – first-generation students, URCs, regions of the country that are less well served.

How important does the U.S. government consider reaching DEI goals to be in order to remain globally competitive in the generation of new knowledge in space sciences?

There’s a great book *Perils of Complacency* about this – just came out. And then just this past month this report – *The Time is Now* – came out from The White House [https://www.challenge.gov/?challenge=ostp-time-is-now&utm\\_medium=email&utm\\_source=FYI&dm\\_i=1ZJN,7L986,WRFZEH,UWK5W,1](https://www.challenge.gov/?challenge=ostp-time-is-now&utm_medium=email&utm_source=FYI&dm_i=1ZJN,7L986,WRFZEH,UWK5W,1)

Is there a relationship between representation (minorities) and retention?

This is in Talking About Leaving Revisited is all about. See chapter 9.

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What actions can be implemented to increase the numbers of Latin grad students?

(1) Fund Minority Serving Institutions. (2) Fund scholarships. (3) Develop networks, social groups, mentoring... Ask your Department Chair to have a monthly lunch for minority students to get together and network.

How can we break the perceived notion that STEM is for men?

I think Hollywood could do a much, much better job. I mean “Big Bang Theory” – really??!! Bill Nye – I do not know any scientists who where bow ties and a white coat. Find a way to get more women scientists come up when you Google search for images of “scientist”

Would it be better for female or male students and educators to reach out to female high school students who are interested in STEM to give them the nudge to go to college?

Both. We all need to reach out, inspire, excite young people about science.

Does the education system in different states affect how many people go into physics education in high schools? How can we address the problem and aide it?

I don't think the state-to-state differences are as important as more vs. less wealthy areas. I think that the nation needs to invest in education in less wealthy regions.

Does accounting for possible critical financial situations adhere to sending people to grad school programs in physics?

I think physics would greatly benefit from better funding of students – UG and grad – particularly from less wealthy backgrounds to study and do research in physics.

Are there significant differences in students' interests in physics between private high school and public high school?lize l

I'm not sure about differences in interest in physics, but I am sure the level of qualification – and pay – are significantly different.

I think family education might play an important role in the fact that fewer females major in physics than males do. Usually, girls get more education in arts than boys, so that they tend to prefer arts and literature rather than math and physics. Does it make sense?

Family education is a big factor – across all education – but I'm sure particularly in STEM. I think the days are dwindling where girls are only encouraged to study art and literature. I hope.

What issues do you face in gathering statistics about non-binary scientists and having them lumped in with women or excluded from the data?

The institutions that are gathering data are way behind society in addressing the complexity of realistic demographics. But I expect that this is one factor that is rapidly changing. Hang in there – the numbers will be in before too long (with luck!!)

A lot of your suggestions are for getting students in general to persist beyond high school in physics. What are specific ideas for keeping women (and other non cis males) interested and enrolling in physics university degrees?

(1) Change stereo types, (2) Make Physics Fun! (3) socialize learning, (4) show there are good, meaningful jobs that benefit society.