Chapter 5

Twelve to Twenty Contact Hours and Research, Too

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Beth Thacker, *Grand Valley State University*
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Chair: Robert Beichner, *North Carolina State University*

David Maloney

I teach at Indiana University-Purdue University-Fort Wayne. It is a joint branch campus of Indiana University and Purdue University, the two state universities in Indiana. Indiana is unique in that it is the only state that has joint branch campuses. We have two in the state—the one I'm at which is officially known as IPFW and Indiana University-Purdue University-Indianapolis, which is affectionately known as Ooey-Pewey.

Students at IPFW receive their degrees either from Indiana University or from Purdue, depending on their major discipline. So somebody who majors in physics will get their degree from Purdue. Somebody who majors in geosciences actually gets their degree from IU. The campus has no residential students. We have about 11,000 students, head count, about 6,000 students Full Time Equivalent, so we're a purely commuter campus and that has a lot of effect on our whole environment. We have a significant number of non-traditional students—service to non-traditional students has been a tradition on our campus. The average age on our campus is 27 and that's actually been going down slightly over the past several years. We award associate degrees, bachelors degrees and we have, at this point, something like 13 master's degree programs on campus. So we have a broad spectrum of programs and degree levels.

The major academic units on the campus are Arts and Sciences, a Business School, a School of Education, a School of Engineering and Technology, Fine and Performing Arts, Health Sciences, and we have an entity called Public and Environmental Affairs.

The physics department, which is housed in the School of Arts and Sciences, is a six-member bachelor's level department, and we will be back up to six members in the fall. We just hired somebody. Our primary mission, as is the primary mission of the campus, is teaching, and the majority of our course load is service courses to either science and engineering majors or to non-science majors. We are like a lot of physics departments at the smaller schools: in order to survive we have to provide service to other departments, and we have the largest number of courses for non-science majors in order for them to satisfy the requirements in the general education component of their programs. The other departments, the chemistry and the biology departments, don't need to provide those courses. They have lots of majors and lots of major level courses, but we need to provide those.

We actually offer three general physics courses. We offer an algebra-based course for engineering technology majors, an algebra-based course for biology and pre-professional students and a calculus-based course, basically for chemists and engineers and the one or two physics majors that show up on our doorstep.

We offer both a bachelor's degree in physics and a bachelor's degree in physics teaching. Typically we graduate about one major a year and in terms of support staff the department has one 3/4-time secretary for the six of us. Now I'm actually, I suspect in one sense, the one of the three of us who has a real advantage because the title is a little inappropriate for me, the 12-20. I actually have 10 contact hours a semester. However, in my past life, my first teaching position was in a place called Wesleyan College in Macon, Georgia where I had 18 contact hours a week, so I'm aware of other environments.

The typical teaching load in our department is about 10 hours. What that normally involves is two lecture courses and two laboratories. The enrollment in the lecture courses range usually from 24 to 60 students for the general physics courses and typically one or two students in the upper level courses. Our upper level physics major courses are taught on a two-year rotation basis because we don't have enough majors to justify teaching the courses every year, and even on that basis we typically only have one or two. Three students in an upper level physics course is a really good deal. The laboratory enrollments average usually about 16 students with a maximum of 24. Laboratories are two hours in duration and the lab meets once a week, whether it's the one of the algebra based courses or the calculus based course. Instructors usually have no assistance for courses or laboratories, so everything with regard to the course is yours when you're the course instructor.

Instructors are expected to hold at least four hours of office hours a week and those are used. The students do come and typically the students will come outside the office hours too. Especially if you have a habit of being around and leaving your office door open and they find out about it—they're oftentimes there.

So that's basically the context in which I teach. When we were asked to give this presentation, we were sent a group of questions, and one of the questions was about research interests. My basic research interest is, as with many other people, generic conceptual difficulties, instructional materials, and I also want to know something about how the different initial conceptions affect what and how the students learn.

I'm almost always doing the research in the context of actual courses in which the students are enrolled. The usual methodology that I employ involves various formats of paper and pencil items: pre-tests, items during instruction and post-tests. I do also have an interest in problem solving, but I haven't managed to get that work out of the preliminary investigation stages yet. I've employed paper and pencil methods primarily for two reasons. First of all, I'm a self-taught educational researcher. I had a very unusual Ph.D. program involving physics, geology and education departments where I was and I did not go through a research apprenticeship as one typically does in developing the Ph.D. I got into research once I was out teaching and had to do it on my own in that initial context of 18 contact hours a week, and I was looking at what was possible. The second reason why I use primarily paper and pencil techniques is the lack of support services. As I indicated, the department has one 3/4-time secretary for all six people and while I could conduct interviews, and I have an interest in conducting interviews, I do not have any resources to have the interviews transcribed into transcripts.

We were also asked us to talk about the major barriers to doing research. In my situation, as I perceive it, the major barriers are basically time, (there's a big surprise, right!) bureaucratic obstacles, which I'll talk about in my context as it affects that significantly, small class sizes, and the fact that we only have one class of each type at any one time. The lack of support services is of course a problem but I'm not going to dwell too much on that.

Time is what I see as the largest obstacle. I think we do have an advantage as physics education researchers in the sense that we can oftentimes make our time serve two purposes, because we can be in the classroom and we can also be doing some research. So compared to somebody doing elementary particle research, (It is highly unlikely we'd hire such an individual at IPFW.) we have an advantage, since their time can't do double duty. Our time can but still there is a lot obviously where you cannot have it overlap, and you've got to have the time to devote to the research. Now the real problem in my experience is not so much finding time but finding good size blocks of time which you can devote to the research, because once again much of the time is involved with teaching and preparing classes and if you're around and you have your office door open, as I said, frequently the students (if you have good rapport with your students) are going to come talk to you and I personally find it very, very difficult, as in essentially impossible, to close my door when I'm in the building. So if I'm around the door is open and almost inevitably as you just get into a task and you're really making some progress, in come the students and there goes that nice block of time that you thought was going to be available to devote to the research. And that sets you back because you put time into getting into the proper framework and to being able to think about the situation and to begin making some progress, and you've got to go back and set it all up again the next time you want to try to go do it.

Another aspect of this is that, as I mentioned, my Ph.D. was very strange. One of the complaints my dissertation director used to always make to me was "Maloney, quit trying to be a Renaissance man." I love teaching and I like teaching very unusual courses, so when the school of arts and sciences comes to the science departments and says, "Is there someone who can teach a core seminar, a science seminar, for this new Masters of Liberal Studies program that we're going to implement?" that's a challenge I like and so I go do it. It also is politically useful because it makes good relations for my department in the school, but if I'm off doing that, that's less time I have available to do the research. But again, as I said, that's a particular personality quirk.

Bureaucratic obstacles, in my experience anyway, are significantly compounded at IPFW. Prior to my teaching at IPFW I taught at Creighton University, 50 miles east of here in Omaha, which is a private school. One of the major changes in my life, when I went to IPFW, was the tremendous difference in the bureaucratic situation.

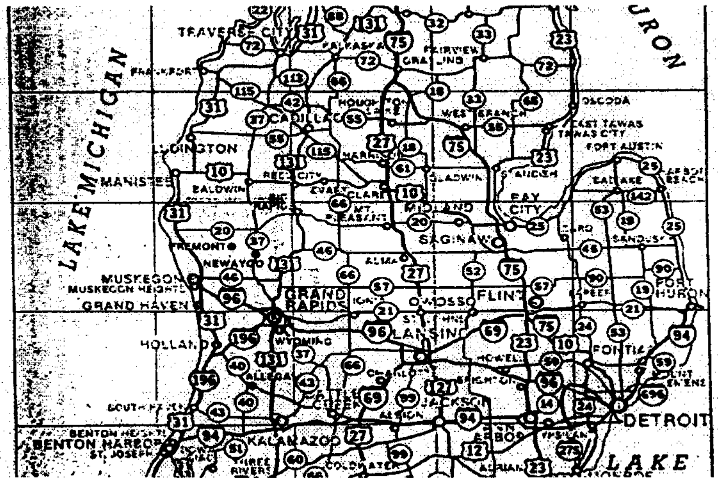
Let me give you one example. I don't know how widespread this is right now, but recently within the last year on our campuses, any research involving human subjects, even research which is "exempt", has to be approved by the human subjects research committee. Now they expedite the exemption because you supposedly only have to submit a one-page form, but because of my situation that research has to be cleared in Fort Wayne and then it has to go cross-state to Purdue to be cleared through Purdue because Purdue is our boss. Any forms or any bureaucratic procedures have to go over to Purdue, and anything that goes over to Purdue automatically takes two weeks longer than if it could just stay in Fort Wayne.

I mentioned the small class sizes. Another difficulty is the fact that we always have just one section of each class running, so there's no way to do something in one class and have a control in another class. You've got one class and that's all there is. There's another, in my view, more subtle obstacle to the research, and in a sense this is something that I think a lot of times we don't like to talk about, but I think really is actually kind of important, and that's my own personality. Now for those of you who know me, don't worry, this is not going to get too bad. I am very interested in conducting research; however I am primarily a teacher and that has several effects. First of all, once I can see how to modify my instructional materials or carry out a study to get some insights into how to modify the instructional materials, I've achieved my primary purpose. It's then difficult for me to go and write that up and communicate with my peers, because as far as I'm concerned the fun's over and it's hard work from there on out. That's something I have to overcome in order to function effectively.

One approach I've used to try to overcome the obstacles has been to look for opportunities to collaborate, and as I mentioned earlier I'm working with several people on several projects. One other point that I would make, and this is something that's in many, many ways very, very important, is the acceptance of physics education research. I am housed in a physics department. Not only that but I did something that in many ways was very dumb. When I left Creighton I was tenured. I went through a tenure process again at IPFW. Not something I would recommend, by the way. So when I responded to the ad at IPFW, and they were specifically advertising for someone in physics education research, I as thoroughly as possible checked with everybody. Will this kind of research activity be acceptable? Will the fact that I'm publishing in things like the Journal of Research in Science Teaching or the International Journal of Science Education, will that be acceptable for tenure and promotion, and I was told, "Yes," and thank God IPFW, both my department and the school, have been very good in that regard. In my situation the department has been very supportive. It's a very nice environment in that way from my point of view, and the administration has been supportive in that regard, but it's something that one needs to think about carefully when one goes into this area.

Beth Thacker

I'm at Grand Valley State University. What I'm going to do is tell you something about both the advantages and disadvantages of being at the type of institution that I'm at.



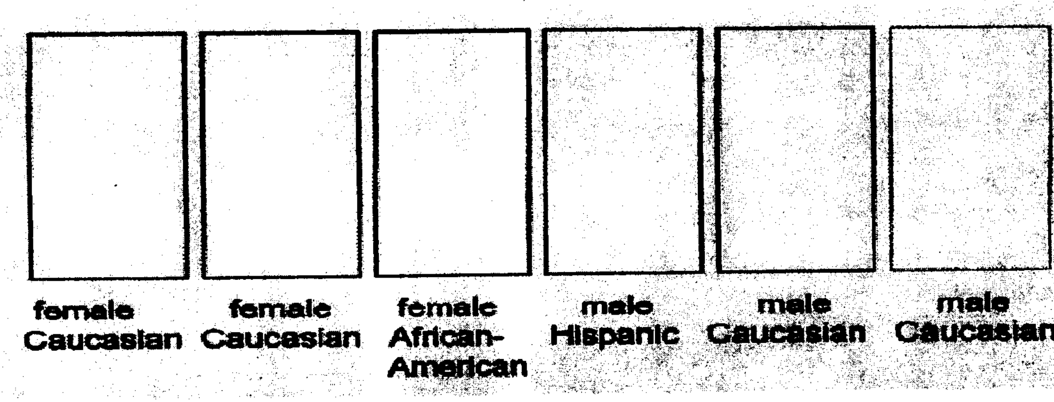
The first thing I have to do is to tell you where Grand Valley State University is. Grand Valley State University is in the middle of a triangle formed by Grand Rapids, Muskegon and Holland. It's in the western part of Michigan and we are right in the very middle of those three cities.

The university was born in 1960. It didn't exist before then. Today it has a student population of 16,000. It's been the fastest growing university in Michigan for the last 12 years.

Grand Valley State University
Born - 1960
Student Population - 16,000
Fastest growing University of Michigan for last 12 years
Some masters programs
Business, Engineering, Nursing, Education...
Highest physics degree - B.S.
Masters in Education with Physics Emphasis

We have some master's programs, business, engineering, nurses, and nursing education and a few others but in physics the highest degree is a bachelor's. We have, however, recently started a master's in education with physics emphasis, and that's a program designed for in-service high school teachers in particular, so the master's level courses are not typical physics master's level courses, they're courses designed for in-service teachers. This we just started recently. The first course ran this summer.

Six tenure-track faculty



I'm in the physics department and our physics department has six tenure-track faculty. The right-most position is a thin line because, as some of you in this room know, we had a position open this year and we failed to fill it. It will be open again next year and possibly another one will be open again next year. I'm also putting this up (same transparency) because we have a fairly diverse physics faculty. How many of you have a physics faculty that looks like this? (I will say that "male Caucasian" describes the characteristics of the person who held the open position previously and not necessarily who we're looking for. All of you may apply.) But we do have a very diverse physics faculty. This is the physics department, and I would also like to say about my fellow faculty members that they are very supportive of research in physics education, in particular to my department head. They are supportive to the extent that I can go in and interview their students, I can put questionnaires in their classes, any of them any time, pretty much, and that's very nice. So on my list that I'm going to start making of advantages and disadvantages I'm going to say that I have a very diverse supportive faculty.

Advantages	Disadvantages
Diverse, supportive faculty	

The title of the session was 12 to 20 contact hours and research too, and I think we need to address that in a big way. I started at Grand Valley four years ago and this was my teaching load that first year.

1st year		
fall	winter	spring/summer
Physics by Inquiry (4 credits) Advanced Lab (2 credits) Math Topics in Physics (1 credit) Senior Physics Projects (1 credit) 2 introductory labs (2 credits) Independent study (1 credit)	Modern Physics (4 credits) Quantum Mechanics (4 credits) Math Topics in Physics (1 credit) Senior Physics Projects (1 credit) 2 introductory labs (2 credits) Independent study (1 credit)	Electricity and Magnetism (junior level to Physics and Engineering) (4 credits)

In the fall I taught Physics by Inquiry by myself to 24 students. I won't ever do it again. I now use undergraduate students who took the course before to help me out. This advanced lab now has four credits. It should have had four credits when I taught it, ok, to give you an idea of what's going on here. The idea, the way physics tries to set things up, is that you have two major preparations, and the rest of this you're supposed to be able to walk in and do by the seat of your pants. Math Topics in Physics is a one-credit course. It's a bridging course for people who have had algebraic physics and now all of a sudden find out they need calculus-based physics. It usually has two to five people, and you meet with them once a week. Senior Physics Project is the only one that's actually a freebie. You just meet with these students once a week and make sure they're working on their senior project.

You teach introductory labs. These are labs where another faculty member is the main instructor, in either algebra- or calculus-based physics, and you just teach the lab. And there are always students doing independent study.

My first year, winter semester, I taught Modern Physics and Quantum Mechanics at the same time. I also taught these other courses, and I also taught in the spring and summer. I taught E&M to junior level physicists and engineers. So that's a first year teaching load.

I'm going to put up a few more for you.

2nd year		
fall	**winter**	**spring/summer**
Physics by Inquiry (4 credits) Advanced Lab (2 credits) Math Topics in Physics (1 credit) Senior Physics Projects (1 credit) 2 introductory labs (2 credits) Independent study (1 credit)	Modern Physics (4 credits) Senior Physics Projects (1 credit) 2 introductory labs (2 credits) Independent study (1 credit) release time to work on improving advanced labs (3 credits)	Quantum Mechanics (4 credits) Math Methods in Physics as Independent study to 4 students (3 credits)

The second year it gets a little easier because you've taught the things once before. So I have courses I taught before. I actually did have some release time to work on improving advanced labs in that winter semester, but I taught again in the summer that year.

So, let's look at year three.

3rd year		
fall	**winter**	**spring/summer**
Physics by Inquiry (4 credits) Algebra-based Introductory Physics (5 credit course — 8 credit hours of instruction) Senior Physics Projects (1 credit)	Algebra-based Introductory Physics (5 credit course — 8 credit hours of instruction) Advanced Quantum Mechanics (4 credits) Independent study (1 credit) Modern Physics Labs (1 credit)	

The reason we want to do this is because that's where I taught the algebra-based course for the first time. Let me tell you how credit hours count in this course. The students get five credit hours. They take two lectures, two discussions and one lab. All right. Let me tell you how it works for me. I teach the lecture, all the discussions and at least one lab. All right. I teach <u>off</u> sequence and that's something my department head did for me because he knows teaching with someone else would not work. There are usually two people teaching the course and they have as many as 100 students in each of their classes. I have 70 to 80, and on off-sequence I have two discussion sections. I meet both of those twice a week and I teach at least one of the labs in my course. In this case I taught one lab in my course. So that's how that works.

The other thing I want to say about this course is I have people to set up my lab for me, but do not have people to set up my lecture demonstrations and do not have people to grade for me, so I grade. I grade homework every week. I randomly grade two problems for 70 or 80 students. I also use journals in my classrooms and I read every single one of them about every two weeks, for 70 or 80 students. My husband thinks I'm crazy.

Again we have two major preparations here that you're teaching; often it's like this. Winter semester you'll have an introductory and then an upper level course. The A.Q.M. course is like the second half of Griffith's book, Quantum Mechanics, right here.

Fourth year was very similar.

4th year		
fall	**winter**	**spring/summer**
Physics by Inquiry (4 credits) **Algebra-based Introductory Physics (5 credit course — 8 credit hours of instruction)**	**Physics by Inquiry (4 credits)** **Algebra-based Introductory Physics (5 credit course — 8 credit hours of instruction)** **Independent study (1 credit)**	

It just looks like two preparations. The point is that it should strike you as truly amazing that anyone with this teaching load does any research at all, and I'm going to put down as my first disadvantage the lack of time to do research.

Advantages	Disadvantages
Diverse, supportive faculty	Lack of time to do research

What you do is you have to figure out how you're going to do it, and so I don't have graduate students and I don't have post-docs, but I do have undergraduates. I use undergraduate student researchers.

Undergraduate Student Researchers Pre-service high school teachers Senior projects, summer research projects Fluctuation in enrollment, length of project

In Michigan if you want to teach high school physics you have to major or minor in physics. This is true of any topic you want to teach in high school in Michigan, and so we have a lot of students who want to teach high school who either major or minor in physics. We actually have a lot of students who major in math and minor in physics. That's our other obvious combination. How can I use them? They have to do senior projects for us, so I can get them for fall and winter semesters for that, and there are also local grants that you can get for summer research projects. For faculty and students, and I've tapped into those. So I can get a student for up to a year, pretty much, to help me do research, so that's the good side.

Then there's the other side of the coin. When I started at Grand Valley I taught Quantum Mechanics to 12 students. That was the size of the class. Last year the person who taught Quantum Mechanics had two. I would think this is a fluctuation at my university because of our size, except that I'm seeing it happen across the country and it's a little bit worrisome. What it has done for my undergraduate researchers is that three years ago I had four and this year I have zero. This fluctuates, and when I have zero student researchers I get a lot less done. The other problem with students doing research is the length of the project. I rarely have them for more than a year because they're undergraduate student, so I will add to my list and I will put as an advantage undergraduate student researchers and I will put as a disadvantage undergraduate student researchers.

Advantages	**Disadvantages**
Diverse, supportive faculty	Lack of time to do research
Undergraduate researchers	Undergraduate researchers

I'm on a nine-month salary. The idea behind this is that I would go out and get grant money to fund me for the rest of the year. In theory, this is ok, right? It makes perfect sense, so when people present this to you, you think it's ok. In practice, it's very hard to get grant money. I know a lot of you have heard that getting grant money is like getting credit in that once you have it it's easy to get more, but to get it the first time is incredibly hard. I don't know if that's still true about getting credit. It used to be when I was a student, but it certainly is about getting grants. When I was a student, also, you could always go to Citibank to get your little start-up fund. Well, I don't know if there is a Citibank NSF agency. If there is I have not found it and I'm hoping that someone in the next session will enlighten me. However, I do get credit and just to show you, between us my husband and I receive at least one credit card offer in the mail each week. Since we have credit we can get more, right? 9.9%, 3.9%, 5.9% no annual fee, all this kind of stuff arrives in your mailbox. Well I keep waiting for another letter to come. It hasn't arrived yet, but I'm sure that it's going to one day. That letter runs like this:

Dear Beth Thacker

You have been *pre-approved** for a $100,000 grant. Simply fill out the form below with your name, department, university, etc. and write a short paragraph (not more than one page, preferably 1/2 page) on how you will use the money. Return the form and paragraph in the pre-paid reply envelope and mail immediately. You will receive a free copy of *The Theory of Fundamental Processes* by Richard Feynman if you respond within the next 10 days. Don't pass up this amazing offer.....

*You are simply required to produce one paper on research in physics education in the next 3 years.

Now you know there's catch because there is a little star here and you are simply required to produce one paper on research in physics education in the next three years. I keep waiting for this letter and it hasn't shown up. I should have asked before I started who had ever heard of Grand Valley State University, because in addition to not being at a large research institution I'm also at a place that no one has ever heard of, and I do not think that helps when I go applying for grants. So I will put as another disadvantage that it's hard to get grant money.

Advantages	**Disadvantages**
Diverse, supportive faculty	Lack of time to do research
Undergraduate researchers	Undergraduate researchers
	Hard to get grant money

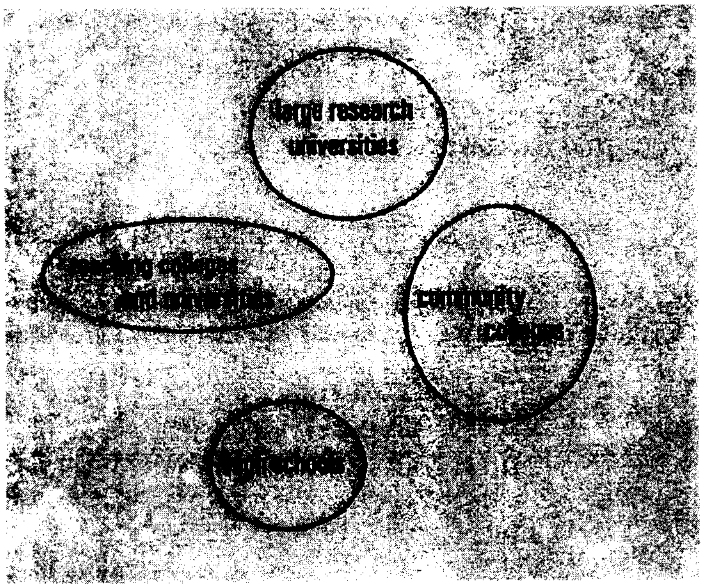
In addition to the physics faculty I also collaborate as I said earlier with the science education faculty members—two inner city high school teachers were writing materials consistent with the Michigan educational goals and objectives.

- Collaboration with science education faculty member and two inner city high school teachers writing inquiry-based materials consistent with Michigan Educational Goals and Objectives in Science Education (MEGOSE) and High School Proficiency Test.
- Workshops for middle school teachers on methods and content consistent with Michigan Educational Goals and Objectives in Science Education (MEGOSE).
- Research in physics education at many different levels and in many different populations.

We also have a regional math and science center at our university. This is kind of a K-12 outreach center but it functions out of the math and science department at the university and they often ask me to do things. I've done a number of workshops with middle school teachers in particular. The reason for bringing this up here is that because of my ties to high school and middle school teachers as well as the supportive faculty I have, I can do research in physics education at many different levels and in many different populations. I have access to this. I have lots of classes I can just walk into and do research in, so I'm going to add to my advantages that I have a broad base for research.

Advantages	Disadvantages
Diverse, supportive faculty	Lack of time to do research
Undergraduate researchers	Undergraduate researchers
Broad base for research	Hard to get grant money

The last thing—historically research in physics education has been done in all of these communities:



Now there may be more, and by this I mean that people who were faculties in these various communities have been doing research in physics education, publishing and contributing to it. At the present time there is a large push to make research in physics education a legitimate and respected part of large research universities in a lot of places and I applaud that push very much. However, I would find it a shame if in the process the research in these other communities was not maintained. I think it should be maintained, but I think it's going to require a conscious active effort to support people who are doing research in physics education at institutions that are not large research institutions, and I think that this needs to be supported from the physics education community itself in order to maintain its roots.

- PER community should maintain its active involvement at the research level in all communities.
- This requires a conscious, active effort to support people who are doing research in physics education at institutions that are not large research institutions.

Rand Harrington

I guess I don't have anything to complain about. I want to start with a couple questions. How many people in the audience have a tenure track appointment or are tenured faculty? Now how many people here have done their research or are currently doing their research in physics education with the hope of getting a Ph.D. in physics education research, or already have a degree in physics education research? There are quite a few. How many people have done their Ph.D. work in physics education research and currently hold a tenure track appointment? Ok, a couple, and of those three how many currently have tenure? All right. This is a problem. This is an issue, and there's a question about preparation: is it the right track to do your Ph.D. work in physics education research in a physics department and then try to go on and teach in a physics department and get your tenure there and get grant money and funding and so forth? There are different ways of doing it and there a quite a few individuals I know here who have done their Ph.D. work in a more traditional field in physics, done research, and come back as post-docs and sort of retooled in physics education research. How many of you obtained your Ph.D. not in physics education research but in a traditional physics field, and then came back and are now doing physics education research? All right, so that's almost the other half if you look at it. How many of those have tenure? Quite a few.

I received my Ph.D. in physics education at the University of Washington. In 1995 the University of Maine, which is the land grant university in Maine, had a statewide systemic initiative through NSL and they decided that they're the only university in the state that offers a Ph.D. program, so they opened up a joint appointment and advertised for a joint appointment between the College of Education and the College of Science. There was a competition between the departments within the college; biology, chemistry, physics and mathematics. They could each have their own search, so to speak, and then they got together and sort of competed about who was going to hire, and physics ended up winning out. I think physics won, at least in part, due to the physics faculty—their enthusiasm and support for someone in their own department doing physics education research. The original appointment was evenly split, 50% Physics, 50% College of Education. I had some good advice to not accept it under those conditions and I didn't, so my majority appointment is in physics. It's currently 60% physics, 40% in the college of education. After the initial five years the funding runs out from the SSI and there's a good chance it will be transferred 100% over to the physics department but currently I do have a foot in both doors, and even if it does become move entirely to the physics department I will still hold onto a cooperating appointment in the College of Education.

My teaching load is actually slightly higher than that of a traditional research physicist. In our department the traditional load is one full course plus one recitation section. I teach two full courses each semester. That's a significantly lower load than my colleagues in the College of Education have. I have offered in the evenings in the last year, a Physics by Inquiry course for in-service teachers under an education course number rather than a physics course number and that has some advantages, and perhaps also some disadvantages.

When I came from the University of Washington to accept this position I was immediately faced with a lot of challenges in terms of starting up a physics education research group there, and there were a lot of choices to be made. I think the first thing I did, and I recommend to those of you who are starting out and who want to start a group, is I sat down and put a lot of thought into writing a mission statement. What is it that I wanted to do? What was I about? It was important for me to articulate this to the faculty in the physics department as well as to be able to articulate this to grant agencies as well as for recruiting graduate students and giving myself a criteria for choosing the projects I get involved with—you can get involved in a lot of things.

There are really three areas that you can get involved in. There's the improvement of the teaching of physics within the department, and I think a lot of my colleagues looked on me as a resource to help them change how they're teaching their courses. Now you have to think about what they mean by that, treating you as a resource. Not necessarily as a research resource. You know if you've been in this field awhile, you start to hear "You're pretty good at installing software and fixing webservers and, you know, you do some neat demo stuff, can you help me out with this demo?" You can really get absorbed into the every day workings of the department and they're all good things. They're all necessary things. But the details of supporting faculty to help them improve their teaching is not the same as doing research in physics education. You have to be careful about where you draw the line as to what you're going to be about.

The second area of major interest for me, and this was probably my own background and what I'm interested in, was the improvement and support of K-12 teachers, pre-service and in-service teachers. This was one of my primary focuses as the physics department begins to take responsibility for training those people that are going to go out and teach our discipline in the field, and to also look at what's happening with elementary school teachers. So I do a lot of work with K-12 teachers.

Of course the third thing is fundamental research on the teaching and learning of physics. You can't do the third thing, the research, without doing the other two. Really, if you really are serious about the kind of research that is going to make a difference, it has to be done in the context of teaching. Being a physics education researcher is related, but is not the same thing as being a physics teacher and coming in and being given your own full course. I strongly recommend this (to those of you that are as physics graduate students doing physics education research) at some point in your career before you go out as faculty. If you have an opportunity to take full responsibility for a course, this is a different ball game than being a researcher, and I think it gives you insight into the real world difficulties of what it takes every day to get up and make sure a course is running, and to learn all the details associated with that. I think that's an important piece.

I have a few other things but I think I'm going to skip some of those and what I'd like to do is something I promised Rachel and some others. I'm going to be a little less formal and I'm going to give you a narrative of a day in my life.

This is slightly fictionalized but everything has happened to me like this. Max is four years old. He's one of my two sons. At 5:00 a.m. he climbs into bed and kicks me in the head. Of course I wake up and I can't go back to sleep because I'm thinking about the tutorial and what's going to happen in class today, so I get up and by 5:40 I've logged on to the school computer with my lap top. I check my e-mail: 5 new messages from PHYSLRNR; one from a local high school teacher; a couple from the main LAB-NET listserv, which I also help moderate. I read the two personal messages and archive the rest without reading them. By 5:50 I have downloaded the tutorial for today's class on electrostatics and by 6:45 my wife is up, has had breakfast, made lunch for the kids and has left for work. She's a nurse. She has to go to the hospital for work in the morning. By 7:10 my kids are awake and the server has crashed so I've lost that last hour of work on the tutorial. I then get my kids ready for school, get them to school by 8:15, by 8:30 I'm in my office checking my mailbox, my real mailbox, the other one. A note from the Public Affairs office about a proposed article for the alumni magazine, phone bill records from the departmental secretary, a note from the associate dean of the College of Education requesting a copy of my career portfolio for the peer review committee. The College of Ed uses words like that, portfolio, and they mean portfolio. Then by 8:40 I'm heading to the teaching assistant training meeting for our descriptive physics course to discuss this week's pre-test on electric charge, examine student difficulties and to go through the latest version of the tutorial, although its not quite the latest because I haven't done those last revisions. We do a verbal description of the changes that will occur before class. Then by 9:45 I return back to my office to find several students at my door. They want to talk about the web-based concept question of the week. We do a web-based concept question every week. I ask them a few questions, make a few notes about their interpretations of the questions that were posted, and then several of them have experienced problems about submitting questions to our database. So of course I call Ed, who foolishly answers the phone, and I send the students to his office for additional help. The chair of the physics department sticks his head in the door and reminds me of the 12:00 departmental meeting and to report on graduate student committee meetings. By 10:15 I'm trying to track down our lab demo specialist to set up a demonstration for today's class. He happens to be at home sick with his kids, so I go to the demo prep room, set up the Van de Graf generator for a demonstration and try unsuccessfully to locate the *good* amber rod. By 10:25 I'm back in my office, revise and print the latest tutorial, the phone rings, its Steve Kaback, a local high school physics teacher, asking if I have a good pre-test on magnetism that he can give his class tomorrow. It's an opportunity for research so I send him an attachment quickly, which means I had to actually check my e-mail again. Fourteen new messages, eight from PHYSLRNR, which I archive again without reading. In my mind I'm going, "what is Dewey doing all day?" Two e-mails from the associate dean, three from students, one from a professor at the University of New Hampshire asking if I can chair a session on physics education at the next New England APS meeting. By 11:00 I arrive in class. I distribute our five-minute conceptual test and a copy of today's tutorial. Peer instructors, pre-service high school physics teachers and science education graduate students, Marilyn and Greg, who I make good use of, arrive, to collect and analyze the conceptual test. Christy and Ed, both physics graduate students, and David Clark, a lecturer, who has volunteered to help out in the class because he wants to learn some new pedagogy, arrive to work with our tutorial groups. This is in our large lecture hall with about 80 students, who are non-science majors. After most of the students have finished the first two pages of the tutorial I show the students the Van de Graf generator. I start the generator with my hand on the sphere and ask them whether they would rather touch my other hand when I am insulated from the ground standing in rubber shoes, or if I'm in my bare feet. After each student records their prediction they are asked to discuss their prediction in their tutorial groups and we then hold a class vote. The majority predicts that it would be safer to touch my hand when I am insulated from the ground because insulators protect you from charge. I ask for a volunteer and then stand on a large piece of foam, place my hand back on the generator and turn it to the highest possible setting. A young lady from the back slowly makes her way to the front of the room. Very slowly, as I feel the charge accumulating on my body, she gets within three feet from my outstretched hand and decides that she might want to change her prediction, but it's too late as a large spark jumps from my hand to her finger and she and I both shriek. We perform the other demonstration while I'm grounded and a brave student volunteers. This time she is disappointed when there is no shock at all and I ask each tutorial group to discuss their observations and to then draw diagrams to account for what they observed. This leads into the last two pages of the tutorial where they are asked specific questions to assist them in developing their models to account for electrostatic phenomenon, specifically the concept of grounding. By 12:10 I'm already late to the faculty meeting. Half the faculty believe the conceptual question I posed to the qualifying exam is too easy. The other half believe the question is too hard. In the end the question is left in. The final result, of course, because the students in our qualifying exam have a choice of which questions they wish to answer, is that the students at least that year decided not to answer that question at all and skipped it in favor of the more standard mathematical derivations. I don't know if that was because it was too easy or too hard. I suspect they thought it was too hard. By 1:00 I'm off to teach Physics by Inquiry. I meet briefly with Marilyn, another graduate student teaching assistant, about section four of properties of matter. We observe students using scales, and we make several notes in our classroom research notebook. This is a very important part of doing research while you're teaching—that notebook in the classroom where I record what happens as it's happening when there are problems, or students have difficulty understanding what is going on. I record some possible wording changes and alternative activities for next semester in the notebook and by 3:10 I return to my office where Ed is waiting for me. He shows me some videos. We watch classroom videos of sixth grade students working through a laboratory session on radioactive materials, discuss directions for his research including the development of a lab on half-life for the algebra based introductory college physics course. The instructor for that course has asked for assistance in developing tutorial like materials for his course. A non-trivial request. By 4:30 Christy has arrived to discuss interview protocols for research on student concepts of sound. We discuss search methods for conducting a thorough literature search and by 5:00 Pam Keefe stops by to discuss our proposal for a sixth grade curriculum materials project on electric charge. We write an electric charge pre-test and she agrees to administer it on Friday and we then discuss our written proposal to the human subjects review committee to get permission to conduct those interviews. By 5:30, there's finally no one in my office, and I examine the NSF career proposal guidelines and I reread my NSF CCD rejection letter and review our comments. Of course by 6:20 my wife is calling to say, "you promised to take Joe (my other son) to hockey practice." I race home, pick him up, and get there just in time. Then I have to pick up Max, we grab fast food, I'm finally home by 7:45 where Kath (my wife) talks to me about fixing that broken window in the playroom and checking the weird noise coming from the front of our rusted out Subaru. By 8:45 I'm doing nifty fluid experiments in the bathtub under the guise of giving my boys a bath and by 9:10 my wife and I are finally sitting down to dinner. By 10:20 she heads to bed and I log on again and start working on tomorrow's tutorial. By 11:30 or so I've logged out and I open the draft of that paper I'm writing on student's conceptions of electric charge and by 1:00 I'm too tired to continue and I go to bed. That's a day in my life.

Bob Beichner

We have about 15 minutes for questions.

Q

I want to know, Rand, if you're having fun?

Rand Harrington

It's a lot of work, but you know what? I love my job. I love what I'm doing. Not every day is like that and I think that there are challenges that are very specific to trying to choose a career path that lies on the boundaries between two disciplines. That's inherent in how our universities are structured but I also strongly believe that the most significant scientific advances that are going to happen in the next century are advances that are going to made by people who exist on those boundaries. That's where the neat stuff is happening and how we actually translate these theories from cognitive sciences into practice in our specific context of physics is going to give us great insight into how people learn, and I strongly believe that that that's what's been missing from the models that educators make, is translation into a specific practice, what we do in the classroom.

Q

Since there seems to be very little time to do research projects which are independent of the teaching assignments that you have, are you pursuing or have you considered pursing what's called action research where you actually do the research as you teach?

Rand Harrington

You have to define what you mean by action research but from my understanding of action research, I think we all do that in that its part of that classroom notebook, that video tape we set up to monitor the tutorial group as they're working through materials, and agree with David in that my initial motivation is to improve how I'm teaching my course. I want my students to get to the punch line; I want them to develop this concept and feel empowered by it. To have this really powerful model to account for some phenomenon that they couldn't understand previously. Yes, later on you look back and reflect and you go, "I have data to support that this change resulted in that," and we have to continue to document that, but that extra step of going beyond what you're doing in order to re-write it for tomorrow and to actually document why you re-wrote it for tomorrow. What is your evidence to support the fact that you can change the wording here and it will have an effect is something—you've got to do late at night, I mean you've got to fit it into your everyday practice. It has to be part of your being about how you are in the classroom and how you are everyday.

Beth Thacker

I haven't succeeded in analyzing it like that. I'm very aware of when I'm teaching and when I'm doing research, and I consider some of the action research that I think I do informally as part of teaching, because I don't do that second step. I have to have it for tomorrow and you do have to have something for tomorrow and you're very aware of it, and you're more focused on that, and you don't have the time until after the semester is over to sit back and to think about why you did that or what was that change that you made.

Rand Harrington

The other thing about action research is if you do a lot of video taping of your teaching and what's happening in the classroom, and you go back and look at that, you realize how difficult it is to be perceptive while you're teaching. The things that are happening that you're not aware of, that are happening in the classroom that are very important but that as an instructor you are simply not aware of or missed. There is a lot of stuff that goes on and when you go back and look at those tapes and you look at what the interactions were when you weren't standing there, you find a lot of very interesting things that are critical, and I think that's a real missing link in some of our research, to really look at what happened.

Q

I want to get back to the overhead you had about the different places where physics education research is taking place, the different kinds of institutions, and ask you how you see maybe other institutions like historically black colleges or gender-specific schools or any of those as being places for that kind of research.

Beth Thacker

I think it should be done in all those different places. I think it is very important because different communities have different views of how to look at physics and I think too often it's not done. It's done in a handful of places that are very similar, and while you find a lot of things, and the similarities that you do find when you look at many different populations always surprise me, but there are specific populations in which you will find different things that you don't find in others, and I think that we need to, as part of our research, look some at gender, ethnicity, and different things that may affect how people understand physics because of their background. So I think it's important to do this.

Q

My situation is a lot like Dave's but I wanted to expand on Randal's observation. I think in our research community much of what we've done so far has focused on students and student learning, but relatively little has focused on teacher behaviors, teacher actions, and the people who have been doing that have been more in education than physics education. But I've had on rare occasions the opportunity to sit back up in the lecture hall somewhere in a collaborative project with a colleague, and Rand was talking about things that go on when you're not there. There's a classic paper in a book called *Cognitive Instruction*, edited by Jack Lochhead, about a conference where there's a transcript of the goings-on in a lab group when the instructor isn't present, and then the effect of the instructor, which is incredibly chaos producing to the students, but there's not only what's going on when you're not there, with a lab group or whatever, but there's what's going on when you are there. Sometime, if you are in an institution where you have big lecture classes, find the time to through a week or two just sit back up in there somewhere.

...end of tape...