Preparing physics teachers for 21\textsuperscript{st} century

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A teacher needs to know…

- Physics itself
- How people learn
- How do we help students learn physics?
A teacher needs to know...

Physics itself
Not just laws and other equations but HOW physicists think — how they come up with these equations and laws and how they convince each other

How do we help students learn physics?
Wealth of knowledge created in PER

How people learn
We know a lot now, and most important is that people learn by actively participating in the collaborative construction of knowledge – STUDENT CENTERED APPROACH
A teacher needs to know…

Physics itself
Not just content-the final outcomes of physics process but the process itself – the process is hidden in the practices and cross-cutting concepts of the NGSS

How do we help students learn physics?
Specific strategies and tools (representations), assessment methods and lots more

How people learn
Knowledge about the brain, embodied cognition, gender composition of groups, identity development (impostor syndrome, learned helplessness, etc.)
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Three crucial issues

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Teachers experience difficulty implementing student-centered teaching (*instruction consistent with NGSS*), despite being taught to do so during pre-service preparation (Simmons et al., 1999).

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What should we do?
The only element of teacher preparation programs that can predict how new teachers will actually teach is the amount of experience with every day instruction relevant to the first year of their teaching received in the program.
Preparation for every day instruction

Physics curriculum (order of topics)
What do we want students to learn and be able to do in each topic? Why?
How will we know that they actually learned it?
What do we know about students’ ideas in this area?
What are productive representations and learning approaches for this particular topic?
What should students know “for sure” to be able to succeed today?
What are good resources? What aspects of those resources match my teaching philosophy?
What will happen in class today? Tomorrow?
Decisions on all of those depend on teacher’s beliefs about teaching

Beliefs: can all students learn physics? Do they come to class full of misconceptions of productive resources? Is learning a quantum state: got it or did not get it?

These are just a few examples. These become as important as the knowledge listed above – EVERY DAY!
It takes time to learn all this, right?
How much time? How many courses?
Rutgers University Teacher Preparation Program has 6 courses over 2 years in which students who already have a physics degree learn to teach physics:

1. Every topic of the curriculum – at least twice

2. Technology, experimentation, assessment, curriculum design – all included
Course work in the Rutgers Physics Program in the Graduate School of Education

Master’s Program (45 Credits)

5 semesters with 6 physics teaching methods courses
(two years with summer between)
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PHYSICS TEACHING METHODS COURSES

- Development of Ideas in Physics
  - First Fall

- Teaching Physics
  - First Spring
  - Using technology in physics teaching

- Engineering Education
  - Summer

- Student Teaching Internship Seminar in physics
  - Second Fall

- Multiple Representations in Physical Science
  - Second Spring
Same framework for all courses: Investigative Science Learning Environment - ISLE cycle

1. Observational experiments
2. Possible explanations
3. Reflections and revisions
4. Check assumptions
5. Testing experiments
   - Do outcomes agree with predictions?
   - Yes: More testing experiments
   - No: Propose different patterns
6. Application

ISLE as a philosophy of teaching and learning physics naturally incorporates development of science practices into student learning of physics and “coincidentally” has the same cross-cutting concepts that are ubiquitous through the ISLE-based curricula that pre-service teachers use.
Issue #2

Teachers experience difficulty implementing student-centered teaching, despite being taught to do so during pre-service preparation (Simmons et al., 1999).
Making student-centered teaching a habit of new teachers

Cognitive apprenticeship

Providing coaching and scaffolding

Slowly removing scaffolding

Independent practice

Contexts that model proficiency

Cognitive apprenticeship to become a new kind of teacher: course work and clinical practice

Providing experiences of learning physics in the student-centered environment

A student learning physics in a reformed course

Providing coaching and scaffolding during micro-teaching; idea of flight simulator

A student in multiple physics teaching methods courses

Some kind of “sheltered teaching”

Giving opportunities for independent teaching with continuous feedback

Student teaching Internship

Slowly removing scaffolding, Giving opportunities for teaching - keeping coaching
Cognitive apprenticeship approach to course work and clinical practice

Providing experiences of learning physics in the student-centered environment

A student learning physics

Providing coaching and scaffolding during micro-teaching

A student in multiple teaching methods courses

Slowly removing scaffolding, Giving opportunities for sheltered teaching - keeping coaching

Teaching in reformed university courses

Giving opportunities for independent teaching with continuous feedback

Teaching practicum with supportive teachers
Cognitive apprenticeship approach to course work and clinical practice

Teaching in reformed university courses

- Giving opportunities for independent teaching with continuous feedback
- Teaching practicum with supportive teachers

A student learning physics

- Providing experiences of learning physics in the student-centered environment
- A student in multiple teaching methods courses

- Providing coaching and scaffolding during micro-teaching
- Slowly removing scaffolding, Giving opportunities for sheltered teaching - keeping coaching
Reforms in undergraduate physics courses: creating an ISLE-based introductory physics course
Students learn physics by following ISLE process working in groups designing their own experiments.
Examples of ISLE labs

Design an experiment to find a relation between a potential difference across and current through a commercial resistor.

Design an experiment to test whether this relation applies to an incandescent light bulb.

Design experiments to determine which of the 3 9-V batteries is better (one of them should be an Energizer battery).

Use the list of available equipment (xx, xx) to pose your own scientific question. Investigate the question and write a report.
Experiencing reformed teaching as a learner is a necessary condition but it is not sufficient.

One needs to practice it as much as possible.
How we make sure that student-centered teaching is practiced every day over 2 years

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We let them observe methods courses instructor and other teachers practice this new teaching and engaged them in microteaching.
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We place them for student teaching internship for 1 semester with the teachers who practice the same way of teaching.
Issue #3

The feeling of isolation is one of the primary reasons for teachers to leave the profession (Darling-Hammond, 2001).
Building a Learning community

- Group work on a big project in every course
- Preparation for an oral exam
- Bonding and communicating during student teaching
Building a Learning community

- Group work on a big project in every course
- Preparation for an oral exam
- Bonding and communicating during student teaching
- What will happen after graduation?
Creating a community of the graduates

Helps new teachers survive
Builds relationships with them so when they are tenured they can become cooperating teachers

Interns can practice during student teaching what they learn in the program
Cooperating teachers can reflect on their own teaching and also contribute to the development of the program
Learning community

- Coursework, projects, microteaching and oral exams together
- Bonding and communicating during student teaching
- Becoming a member of the physics teaching community for life
How do you make a learning community?

Real? Virtual?
Funding?
Release time?
Teacher pay?
Meetings in person
Working together as they are used to
Evolution of the Meetings

- Day of the Week
- Classroom Experiences
- Positive Attitude
- Pedagogical Discussions
- Physics
- NEW: Analysis of student work
Teachers Miss Physics…
Why does a balloon make a loud sound when you pop it?
Physics: Teachers Contribute

Tovi Daniel Spero
November 15

Here are the movie links I had for us at the meeting last night. Of course I use more but this is just a few I use during the year.

11/14/14 Meeting - Movie Physics - Google Docs

https://www.youtube.com/watch?v=52cu-8FX5OQ
https://www.youtube.com/watch?v=OiiXUei15fQ

Spaghettification
https://www.youtube.com/watch?v=uNc-JLysk9Y

Interstellar
https://www.youtube.com/watch?v=iu7QDqPMq3Y

No noise
giant wave
GR time dilation
black hole entry velocity????

www.theuniverseandmore.com
Remote Attendance

- Skype
- Google Hangouts
- GoToMeeting
One of Friday night meetings
Teacher-Led Workshops: Standards Based Assessment
A long time ago I devised a method of teaching mechanics or rollerblades. Not only do I practice this method in the classroom with future teachers but we also rent a rink once a year to help them learn technical details.
Virtual Community

I'm a little confused about heat engines. They've never been my strong point at all, and this is my first time teaching them in AP2.

According to the books, Efficiency is W done by the gas / Q in.

Work done by the gas then get defined as Qin - Qout.

I understand that, but it's not consistent with something else.

Brian, awesome discussion, this is how I see it:

for Qin = W + Q out, + W refers in this case to work done by the gas on the environment. The return of the gas to its original state is not considered.

Take for example a simple steam turbine. Steam in provides the Qin. W out is the spinning blades, Q out is contained in the exhaust steam. Qin = W + Q out.
OVER 60 messages per month beginning 2004; over 80 members; meetings twice a month (from 4 to 25 teachers).

Just this past Friday I had 17 people staying from 4:30 pm to 7 pm. It was 1 am in Slovenia and they were in the School of Education in New Jersey or joining remotely
How do these experiences affect my teachers?
Danielle Bugge, graduate of 2010
Rich Therkorn, 2006 Graduate, her cooperating teacher during student teaching
Creating a mini-community in their school
A happy high quality physics teacher – a member of the community of like minded

Community-based striving physics teacher preparation program

Graduates of the program-physics teachers and their school districts

Physics department willing to change its courses and to trust future teachers to teach
Rutgers program graduates 6.3 physics teachers every year since 2004

Is 6.3 physics teachers per year a small or a big number?

What is the US average?

0 - 1.....
Are they good teachers?

80 observations of their teaching in the schools – they do in fact PRACTICE STUDENT CENTERED INSTRUCTION! (we use RTOP)

They have excellent gains on standardized physics tests. (FCI and CSEM – H-gains of 0.4-0.6)

Enrollment in physics in their schools increases.

They participate in the development of new curriculum materials (http://pum.rutgers.edu) and teach some of the courses in the program.

AND THEY DO NOT QUIT – the retention rate is over 85% after 5 years.
What does it mean for us?

Yes, we can prepare teachers to teach physics in the 21st century.

But there is no end to teacher preparation program.
Thank you!

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http://pum.rutgers.edu

Etkina, E., Using early teaching experiences and a professional community to prepare pre-service teachers for every-day classroom challenges, to create habits of student-centered instruction and to prevent attrition. Book chapter accepted for publication in “Best practices in physics teacher preparation”.


