



THE UNIVERSITY *of* EDINBURGH
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Narratives and Fictions about Physics Education

The following two short stories were produced as part of the research project “De- and Reconstructing Physics Education: A Female Gaze”. For more information, please visit the [project website](#).

Maya

The ninth graders are nervous in Maya's physics class on Monday morning – and understandably so: This is their last class before their electricity exam on Wednesday.

"Before we go into some preparation for Wednesday, does anyone have any questions about the exam?", Maya kicks off the class.

Three hands immediately go up.

"Julia?"

"Misses Williams, can you explain again what Volts are?"

A boy in the third row blurts out, "It's potential!"

"Yes, Max... although next time please raise your hand first. Volt is the *unit* of the physical *concept* potential. That was a good question, Julia, it can be tricky sometimes to not mix up the two. Let's practice this a little – Which one is resistance?"

"Concept", the boy next to Max retorts.

"Exactly James, resistance is the concept, measured in Ohm. How about Ampere?"

This time a girl raises her hand.

"Yanicia?"

"I think Ampere is about how much electricity is flowing, right?"

"It's counting how many little electricity particles go from one side to the other?" Maya takes a moment to think about this answer.

"You're on the right track there, that's what it means. So would you say Ampere is the unit or the physical concept?"

"Mmmh, the unit, I think."

"Correct. And what is the concept that we measure with the unit of Ampere?" James knows the answer again. "Current", he calls out.

Maya shoots him a look for speaking without being called on, but the answer is correct, so she nods.

"Alright I think we've got this down. Any other questions?" A moment of pause, Maya studies her students' faces. "Christina? All clear?"

"I.. think so?", Christina replies unconvincingly, making her statement more of a question.

Maya invited me to join her class for two weeks as a guest. She started working as a full-time physics teacher six years ago and feels confident in her work; but she recognizes that teachers, too, are human, and in a strive for continuous development, she arranged for me to observe her teaching practice to help her reflect on it.

Another girl in the first row raises her hand. "In the book there was something about a short circuit. Is that relevant for the test? And also the exercises on page 81; will this be part of the exam? And then there was this formula that we never even talked about in class—" she stops herself to turn around and angrily glare at the boys two rows behind her, whose heckling has now turned into loud laughter.

"Just chill, Alice", Max says, "the exam will be easy."

"Come on, Max, some of us need to work at it."

At that point Maya intervenes and answers Alice's detailed questions about which pages of the book are relevant as exam preparation. The boys in the third row are unabashed by the impending test and start whispering, meanwhile, Alice and her friends in the first row take notes on Maya's explanations. Fifteen minutes of the class have already passed when Maya introduces the activity she has prepared: In groups of four, the

students will work on an exercise sheet tackling one subtopic of electricity, and then in the end present their answers.

Groups are forming almost naturally – Alice and Christina team up with Max and James, but in a class of 29, there is one student left over. It's a girl who sits alone in the last row. She stands up from her seat, unsure where to go. Maya reacts quickly: "Sarah, why don't you join Alice, Christina, Max and James?" Sarah, the girl, looks relieved and scared at the same time, but she sits down with her group. The others mumble but don't protest. They fetch their learning materials on electrical circuits and start reading through the problems.

"Chrissie you take the notes for the presentation later", James says.

"Sure thing", Christina empties her pencil case. "Look at that, I have five shades of blue for five problems, it's perfect!"

"Thanks for doing the writing, Chrissie, you always make the prettiest posters", Alice sighs and they start pondering the first problem. It contains a drawing with a mix of parallel and series circuits, three light bulbs and a resistor, asking them to calculate the current in one of the circuit's branches.

Alice is the first to speak up: "So, I'm not sure exactly, but I think this one is a parallel circuit, and we have a total current of—" she gets interrupted by Max "Nah, look at the sketch. It's in series."

James adds, "It splits at this node and comes back together after the light bulb, so at this point we have $\frac{3}{4}$ of the total current."

The group, that is, mainly James and Max with comments from Alice, are still debating the approach, when Sarah finishes the calculation.

"Here it is", she says timidly and turns around her page so that the group can see her solution.

Alice turns up her nose. "Yeah that's what I did too", Max declares. James makes a face and Christina just copies the

solution. After a moment of awkward silence, the group continues. Sarah finishes the worksheet in half the time of the others but makes no more attempts to share her solution and is in fact mostly ignored by her classmates for the rest of the group work.

Christina indeed makes a very pretty poster and in the final phase of the lesson Max and James present the group's solutions to the rest of the class. Maya seems content with the overall engagement and success of the group work. She gives her class an encouraging smile.

"Are we all prepared for Wednesday?"

Christina still looks a little scared, Alice seems satisfied, Sarah's face is hard to read. The boys are confident "Electricity is so easy...", one of them confirms and the others nod in agreement. The school bell rings, the students pack up quickly and rush out the door for their break.

Sarah takes her time until she is the last one in the classroom, and instead of leaving she walks up to Maya.

The year before, in their English class, all students did presentations on a topic of their choosing to practice public speaking. Some talked about their favorite book or movie or actor, Sarah presented on nuclear energy. Baffled by her choice of topic and overall presentation in its complexity and detail, the English teacher approached Maya in the staff room that day. As excited as Maya was about having an exceptionally interested student – and a girl on top of that – she had little flexibility in adapting the set curriculum for a single more advanced learner. She did what she could, though, to encourage her to pursue her interest outside of school.

“Hey Sarah, what can I do for you? Feeling good about the test on Wednesday?”

“Yeah, thank you Mrs. Williams, electricity is fine, but I actually wanted to ask you about the Doppler Effect... I've been thinking about it a lot lately, and you know, I have a laser at home that I was playing around with; I pointed it at the wall and moved it back and forth very quickly, but I couldn't observe a redshift, or any difference at all really. Why do you think that is?”

Maya smiles and glances at the clock. “Well, the break is not long enough for us to dive into this right now, but let me note down for you a book where you can find all the answers on this” – she takes out a pen and paper – “This is an *introduction to electrodynamics and optics* for uni physics courses, so don't be scared if there's some math in there you haven't gotten to yet.” She hands her the paper. Sarah's eyes sparkle as she gently folds the note and carefully puts it in her pocket.

On Wednesday, the class is already awaiting Maya when she enters the room two minutes early with a stack of tests: Alice with her heads bent over her notes, Max and the boys laughing, Christina sharpening her pencil, Sarah quiet and almost unnoticeable in the back.

They get ready and Maya hands out the papers; the test has started. The room is quiet except for the occasional turning over of a page and the constant, hurried scratching of pens on paper. After 35 minutes, a little more than halfway through the test, Christina unexpectedly laughs out loud. Maya looks up, some heads turn, but the others are barely disturbed. Maya studies her face – she seems amused and doesn't stop giggling until the full hour of the exam has passed. When collecting their papers, Maya stops at Christina's seat. “Do you want to talk about this?”, she offers gently.

“Sure”, Christina is still giggling. “Let's talk about it.”

Maya is almost surprised about the affirmative answer. “How about next week, then? Stop by on Monday after the last class and we can have a chat just the two of us.”

Usually it takes Maya two weeks to mark the tests, but in a burst of motivation over the weekend, she finishes all 29 of the tests before Monday. She grades them blind, each paper is identified with a randomized student number and only matched back to the name after she's finished grading. Overall, the results of the exam are unremarkable, perfectly normal -- some of the girls scored As, some got away with Cs, a few Ds among all genders, nothing sticking out, really.

She arrives in class on Monday morning with a stack of graded exams. The whispers grow into an agitated thrum as she starts to hand them out. Alice got an A- but seems unimpressed -- she expected nothing less. Max upon receiving his exam proudly snorts out: “Maaan I'm so smart, I'll be a doctor of something one day!” He got a B+. Christina's test is marked with an F but curiously, she doesn't seem too shattered by it; Sarah only takes a very quick glance at her grade and then packs the test away; she brought the textbook Maya recommended and while the rest of the class examines their results and compares answers, she starts reading the *Introduction to Electrodynamics and Optics* under her table.

Fifteen minutes later, the class is still agitated – there is no question of continuing with a proper lesson. Maya reads her students' mood and decides to go with it and take advantage of their emotions. She announces the next topic: Optics.

The boys are immediately excited: “Are we gonna do quantum mechanics??”

Maya smiles, “You heard that somewhere in movie? No, optics is about things like refraction and reflection, and light and lenses.”

The disappointment is only minimal. Eric, third row between Max and James, has another idea:

“Can we at least talk about Oppenheimer? I watched the movie, and it was really cool. I would have wanted to be a physicist there in Los Alamos.”

Alice rolls her eyes. “I can't really see why you would ever wanna be a physicist; The sooner I can be done with physics, the better. No offense, Mrs. Williams, you're a great teacher, it's just not really interesting and I don't see why I need any of this. I mean, I'll never just randomly build circuits and calculate the current in them.”

Maya reacts promptly, “You don't see how physics is relevant? Oh I think we can change that, and actually optics may just be the perfect topic. This will be a lot more about understanding phenomena and less about calculations.”

Rebecca in the second row lightens up, “Can we do something with eyes? I saw a TikTok video about why some people need glasses.”

“That's actually a great idea, Rebecca, we should be able to cover that. It's wonderful application of lenses.”

This idea brings up another one for James: “Oh my mom just had her eyes lasered, so she doesn't need glasses anymore; Are we gonna talk about that too?”

More students start throwing in ideas now, and Maya, positively surprised and quite happy, watches them get more and more excited.

“How about this”, she suggests, “Until our next class, you all think about a topic in optics you're interested in or any questions you have. TikTok, movies, your everyday life, the internet,... any source of inspiration. Write it down on a piece of paper and drop it in a little box I'll put up here.” The excitement is tangible as Maya dismisses the class for their well-deserved break. In the

back of her mind she thinks about how she could make time in her schedule to prepare the lessons around the students' input. Most of their suggestions are related to optics, but not part of the standard curriculum. She'll have to do some research into bio physics and medical applications to be able to competently cover those topics; But if she can catch the class with this, she thinks, it'll be worth the extra effort.

In the afternoon, Christina comes back to the physics classroom for her 1:1 appointment with Maya.

“I can imagine your grade on the test wasn't quite what you had hoped for... And I know you can do a lot better .”

“That's the thing, Mrs. Williams, I don't think I can... I'm really a lost cause in physics. That's why I was laughing, you know, it was so funny because the exam showed me that nothing you taught me has sunken in. I did try to prepare for it, but I was laughing because it was just so hopeless. I couldn't figure out a single thing.”

“Oh Christina...”, Maya tries to counter.

“Oh it's not you, Mrs. Williams, I know you're a good teacher, I guess I'm just not smart enough. I'm just here because I have to be, and I can't wait to be done with it.”

Maya's first instinct is to point out her students' successes and try to rebuild some confidence, but the way Christina declares her inability to do physics makes it sound like a closed case, a fact she has accepted. Christina isn't here to have her mind changed by her teacher; she is merely informing her.

After a few seconds of thoughtful silence between them, Maya takes a breath. “I was you, you know. I was a lost cause in physics. I hated it, and I really sucked at it in school. Pure coincidence that I ended up studying physics, and even more

surprising to me and everyone around me that I finished my degree in physics.”

Christina did not expect that, and Maya can see in her eyes a different curiosity now.

“Seriously? I would not have guessed ...”

“That’s the point”, Maya gives her a wink. “Sometimes we don’t fit expectations, sometimes we’re not what others think we can... or should be. Only you can know. I can’t tell you if physics is the right thing for you, but if I can give you one piece of advice it would be: Don’t give up just yet. And don’t ever say that you’re not smart enough.”

Eva

It had already been dark for a few hours but neither Eva nor the rest of her study group noticed. They had been working on their quantum mechanics assignment that was due at the end of the week, and had made great progress for the first few hours, but now they were stuck on the last exercise of the sheet.

Consider the scattering of a particle by an impenetrable sphere.

Derive an expression for the s-wave phase shift.

“Four pages of differential equations and I gotten... nowhere”, confessed Julian. “You two got anything useful?”

Eva stared at her notes. “I gotta try it out but I think, you know, since we’re talking about a spherical potential, for me the spherical Bessel functions come to mind.” She’d tried a few different approaches, but this seemed most promising to her.

“Let’s approximate it as a basic solution to the Schroedinger equation”, Julian suggested.

She looked up from her notes. “That seems a little farfetched, don’t you think? I mean, why do you think—”

Robin jumps in, “Good idea, we should try. At least solving the Schroedinger equation is something we covered in the lecture.” -
- “Ok let’s start with some substitutions to simplify the equation.”

“I’m not convinced”, Eva tried one more time but the rest of her study group were already back in the zone and didn’t register her assertions.

The empty lecture hall they had occupied with their textbooks and laptops and worksheets was an almost windowless room that to Eva always seemed to exist outside of time. It was also where she had taken all exams of the previous two semesters – she flinched at the memory. Almost half of which she had initially failed, and only achieved a pass on the retry exams. It wasn’t that she didn’t have the competence to solve the problems, but as soon as she would finish putting her name and student number on the first page she’d feel anxious, her concentration would drop and calculations she had done a number of times flawlessly in exercises would suddenly refuse to puzzle themselves together in her mind. *Why not languages?* She would then in her mind hear her mother say. *No*, she’d try to remind herself, *I want to do physics. Focus. Don’t prove everyone right.* In such moments she’d think of the disbelief in other students’ reaction when she introduced herself at parties as a physics student: “Really? You don’t look like a physicist”, was something she’d heard more than once, both from fellow physics undergrads and students of other programs. Or the surprise of her peers upon seeing her on the first day of the third semester. “You’re still here?”, one had commented with amazement so genuine she almost didn’t register it as condescending. More than once she had considered dropping out, but at the end of the day she really did find joy in several pages of integrals that would simplify to one neat equation describing the phenomenon at hand. Dirac’s formalism and the math of quantum mechanics bore a beauty to her that, despite the setbacks and failed exams, she wanted to understand better.

Eva sat back for a moment and paused. Both Julian and Robin were focused on their calculations, but she already saw that it

wasn't going to work. Another hour passed until Julian dropped his pen in frustration.

"Alright I'm giving up", he declared with a sigh.

"Well, I still think we could try—" , Eva made another attempt, but was interrupted by an equally frustrated Robin. "What were they even thinking with this problem! I'm not sure this is something we can solve at all with the tools we've been given so far."

Julian started packing up. "Almost 10pm and we haven't had a proper dinner. I'm gonna call it a night, we'll see the solutions in class on Friday."

"Come on, boys, you can't just give up!", Eva wasn't done.

"There's still a few routes we haven't tried, I think--"

"Sorry, too tired, too hungry", Julian gave her an apologetic smile and shrugged.

Robin followed his lead, "Evie, honey, you're wonderful and sweet for trying to motivate us, but it really is a lost cause... Go home, we'll see you in class."

"I—", she, too, was tired and hungry and exhausted, but also determined and irritatingly drawn to the challenge.

"Good night, see ya!"

The sound of the door closing behind them echoed in the now almost completely empty lecture hall. She sighed. *Physics really isn't about being a genius, just about being persistent*, she thought. *I'm not genius, but I might be just stubborn enough*. She would spend another two hours that Tuesday night, and all of her free time during Wednesday and Thursday on the problem, until after countless hours and many more tries she eventually got a

sensible result. She double checked her calculations, it had turned out she didn't even need the spherical Bessel functions, so the math wasn't actually that complicated; her logic was implacable, and her results were congruent with experimental evidence. She actually got it. A warm feeling – perhaps pride? – filled her as she looked down on her work; she wasn't usually one to crack the hardest problem. She didn't think of herself as brilliant – normal, maybe good sometimes, but certainly not brilliant.

She could hardly hide the excitement in her voice when she called Robin and Julian, and walked them through her steps. There was a brief moment of silence, then they laughed and applauded her. "Congrats, Evie, you did the impossible! I don't think anyone in our class solved this one", Robin acknowledged. She giggled and they all agreed to meet outside class the next day like they always did.

It was a Friday morning in January, the air was chilly but the mood was light. "What was up with that last exercise?! Probably they were amused by the thought of all of us cramming over an impossible problem for a week", one of their peers, Phil, joked. Everyone laughed and nodded in agreement, "Yeah, that one was just unfair."

"Well", Julian paused dramatically. "We solved it." All eyes turned towards him.

"You're kidding! I don't believe you", Phil laughed.

"Nope, he's right, we got it!", Robin confirmed. "Accept it Phil, we're just smarter than you", he added jokingly. Julian laughed and gave Robin a high five.

“Not exactly”, Eva said quietly. She didn’t mean to, the words were just coming out. “Technically, I got it.”

The laughter stopped suddenly and gave space to an abrupt silence. Eva couldn’t say if it was disbelief that *she* would have been the one to solve the problem, or just shock about her audacity to embarrass her friends like that in front of everyone else.

“Right”, Robin said after a pause of a few seconds that felt like a cruel demonstration of time dilatation. “*You* got it.” He tried a half-hearted smile in her direction.

Eva immediately regretted her words. What had come over her? She didn’t like the spotlight anyways, why did she have to say that? She didn’t really care about what the others thought, and she sure as hell didn’t want to jeopardize her friendship with Robin and Julian over this – she genuinely liked both of them, and not just because a study group was, as most would agree, necessary for persistence in undergraduate physics.

“I mean, it was mostly luck. I basically just stumbled upon the right approach”, she tried to relativize. “Sorry, I didn’t mean to sound arrogant, you all know I never get it right”, she attempted a joke, “of course it was our group discussions that really pushed us in the right direction.”

Before anyone else could reply the professor finally arrived and they all hurried into the lecture hall, taking their places. When they reached the discussion for the last problem on the exercise sheet, all eyes turned to Eva and the professor invited her to demonstrate her approach on the whiteboard. She did as she was asked, though the feeling of pride and excitement she had felt the day before suddenly dissipated. She presented her

calculations with the monotone confidence of someone who knew that they were right but who had forgotten somewhere along the way why they cared about the issue in the first place. When she was done, there was that brief moment of silence again. Then the professor spoke:

“Who helped you?”

Eva turned red, didn’t answer and sat back down at her desk in the last row, which allowed her to slip out unseen a few minutes later and lock herself in the bathroom. Nothing of the pride she had felt was left. She thought of the funny feeling in her stomach when someone in her cohort had made a joke that she was too pretty to be smart, and had meant it as a compliment; she thought of the teaching assistant systematically overlooking her raised hand after she had gotten some answers wrong in the first tutorial of the year; she thought of the times she had been told that the history faculty was on the other side of the street when she’d entered the physics building, as if she’d wandered in here by mistake. She closed her eyes for a moment and took a deep breath.

From then on, she stopped apologizing for her achievements; she started repeating her ideas with assertion and confidence when overlooked; she hated being rude, but she learned to interrupt others when they interrupted her.

I met Eva as TA during her PhD in theoretical cosmology. In her tutorial, she keeps a tally: Every time someone says they can’t do this or they can’t figure out that, she corrects them – “of course you can, what makes you say that?” – and the class logs it. Five strikes make a cake.