

Women of Science: Coaching High School Girls for a Science Competition

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Arts, Humanities, and Social Science Capstone Project

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Introduction

For my AHS Capstone project, I spent a semester coaching a team of girls at Needham High School for the Women of Science Competition hosted by Bedford High School. I taught five lessons, ranging from a half hour to an hour and a half in length, over the course of six weeks. These lessons were intended to prepare the girls for the four different events of the competition, which included two engineering events and two scientific knowledge events. In the end, though, I ended up spending three of the meetings primarily focusing on one of the engineering events, and the other two meeting on two of the other events.

The four events are Anything Goes, All About the Atom, Bohr's Family Vacation, and Humpty Dumpty's Heroes. Anything Goes is a station event, with ten stations hosting physics, chemistry, biology, and earth science activities. All About the Atom is a 100 multiple-choice question test with questions regarding atomic models, the periodic table, Niels Bohr, atomic structure, the electromagnetic structure, and nuclear chemistry. Bohr's Family Vacation is a pre-engineering event for which the girls built a cable climber to carry a few LEGO people over a chasm. Humpty Dumpty's Heroes is an egg-drop.

I spent the most time on Bohr's Family Vacation, because it was the most obvious event to be unprepared for. If the girls did not know the answers to the questions on the All About the Atom test, or were not able to answer correctly for an Anything Goes station, it would not be as embarrassingly obvious as if they did not bring a device for Bohr's Family Vacation. I also spent more time on this event because I vastly underestimated the amount of time it takes for people inexperienced in design to design something.

As a part of my personal learning process, I wrote a detailed reflection following each lesson. These reflections include a basic meeting plan, the learning objectives, a summary of what happened during the lesson and my personal reflections on what I think went well or poorly and what I could have done to improve the lesson.

Individual Meeting Notes

Meeting 1: October 9, 2013

Needham High School

Attendees:

Jen

Meeting Plan:

1. Introductory Presentation (Appendix A)
 - a. Who I am, qualifications, interests
 - b. Competition, with details about each event
 - c. Calendar
 - d. Possible preparation methods
2. Feedback
3. Instant engineering event
4. Judge instant engineering

Goals:

1. Introduce the girls to the competition
2. Have girls get to know one another
3. Get the girls excited about the competition!

Meeting Recap:

The plan for this meeting was to introduce the competition and get the girls excited enough about it that they would stay. My plans were immediately thrown off, however, when 'getting the girls excited' became 'get the *girl* excited,' as only one student, Jen, showed up. As this was the first meeting, I had not had too much practice with sudden adaptation to changes, so I soldiered on ahead with my original meeting plans.

Since I was lecturing to a single student and the teacher, Ms. Luck, the presentation became much more personal. Jen and Ms. Luck both brought up questions and concerns regarding the competition events and my methods for preparing for them, and I was able to pause the presentation and answer them immediately instead of waiting until the end. Jen was excited about preparing for the All About the Atom event and by my suggestion of visiting Olin to look at different scientific machines, but she seemed less enthusiastic about the engineering events.

After we finished the presentation, and Ms. Luck and Jen had made their own suggestions regarding preparation (for example, using the website Quizlet to make flashcards for the All About the Atom event), we moved on to practicing for the instant engineering event. This activity was more to engender enthusiasm than to actually practice, as according to the competition website it's quite likely that the instant engineering event will be either an egg drop or catch. The instant engineering event I planned for that day was a tower building competition, where we were given 20 minutes to build a tower that could support the weight of a juggling ball. The tallest tower to successfully hold the weight for thirty seconds would be declared winner.

As Jen was the only student, Ms. Luck and I participated as well. At the end of the twenty minutes, I had the tallest structure, Ms. Luck's the second, and Jen had the shortest. However, the base of my was insufficient to support the weight, so I was disqualified; likewise, Ms. Luck's tower needed a

bit of prodding to balance correctly (though it did hold the ball eventually), so I declared Jen and Ms. Luck tied.

By this point it was 3:45 and Jen had to leave, so we wrapped up. I did not do a feedback session, not for any good reason but because I forgot.

Reflection:

There are four things that I would improve, if I were to do this lesson again. First, I would edit my presentation to include less personal information. Second, I would print out an 'instructions' sheet for the instant engineering event. Third, I would more rigorously run the testing portion of the instant engineering event. Finally, I would make sure to lead the feedback session at the end. None of these were extreme problems, but the lesson would definitely be improved with those changes.

I would edit my presentation because I think that the number of interesting things about me that I listed was too high. This happened because of feedback I received from my fellow AHS Cap classmates; originally I had no personal information about myself in the presentation. When someone suggested I add some personal information, I added six extra slides and nine pictures. At least four of those pictures were entirely superfluous, though Ms. Luck and Jen were both impressed that I fire hoop.

I would also create an instructions sheet for the instant engineering event because I think it would add some necessary organization. When we started the event, I realized that I should time it, and decided semi-arbitrarily that we should have 20 minutes. I should have set out exactly what we were doing, with a list of materials and judging protocols, so that we would all be on the same page throughout the entire activity. As it was, I was a bit uncertain in declaring the competition a tie between Ms. Luck and Jen, and it would have been better if I had been more certain.

The fourth change I'd make would be to actually include the feedback session. Again, I do not have an excuse for not doing this; I just forgot.

Meeting 2: October 16, 2013

Needham High School

Attendees:

Jen

Meeting Plan:

1. Attempt design for Bohr's Family Vacation

Goals:

1. Have a general Bohr's Family Vacation device design

Meeting Recap:

For this meeting, I tried to get Jen to design the cable car. I did not have a good idea of how to lead design without influencing it, so I tried to try to improvise during the meeting. I brought a few mousetraps and a length of 1/8" cable so she could play with them, though playing with mousetraps is seldom a good idea. Other than that, the materials I brought for design included pens and engineering paper. Jen was really awesome about talking through what she was thinking but was a little off in her terminology. She understood that the spring of the mousetrap would be used to store potential energy, and that one way to do so would be to attach a lever arm and a string to the end. However, the design did not get very far as Jen had a dentist appointment and had to leave after about twenty minutes of designing.

Reflection

I was worried going into this meeting, because I've never tried to lead a design activity without having an influence on the design itself. As it turns out, my worries were well-founded; I had an extremely hard time trying to have Jen design the cable car. I unfortunately have an idea of exactly what I would make if I were doing this project alone, and it was very difficult to not let that seep out. It was especially difficult because, as far as I could tell, Jen had never designed anything before, so she was learning both how to design and trying to figure out how to make a cable traverser.

I think my main problem was going to the meeting with the hopes that Jen would be as experienced in design as an Olin student. I've forgotten what it's like to not have any experience of making things, and, being cloistered at Olin, I rarely come into contact with inexperienced designers. There were many awkward pauses when I tried to explain something to Jen, or she tried to explain something to me. Since the Bohr's Family Vacation event is the event needing the most preparation, I'll be continuing the design attempts next week, but I think I'll start the lesson with a few pictures explaining how mousetrap-powered cars and cable climbers work.

Meeting 3: October 23, 2013

Needham High School

Attendees:

Lily

Meeting Plan:

1. Go through Introductory Presentation (Appendix A)
2. Go through Mousetrap Car and Cable Climber Presentation (Appendix B)
3. Attempt Bohr's Family Vacation Design

Goals:

1. Have a general Bohr's Family Vacation device design

Meeting Recap:

Despite not wanting to use many presentations, I found myself beginning the third meeting with a presentation. Since Lily had never seen a mousetrap car, and I did not have one on hand, I figured that the easiest way to explain the concepts was through pictures. I also knew that Lily was not too familiar with the concept of a machine traversing a cable, so I included as many examples of cable climbers as I could find. Oddly enough, almost every online source regarding cable climbers has something to do with space elevators. Fortunately, those are more complicated than what we're trying to design, as they have to counteract gravity in order to climb, and ours just has to traverse the cable. The last bit of the slideshow had examples of what a laser cutter (such as the one Olin has) can do. I also brought in a plastic fish and a particle board donut that had been cut using the laser cutter.

After the presentation, we tried to design the cable car. Once again, this was a bit awkward because there was only one girl there, and I was trying to not influence her thinking too much. Lily also seemed quite shy, and was nervous about trying to draw her ideas. When I explained concepts to her, she would say that she understood, but it was in the voice that I use when I know I should understand something but do not quite get it. I think I was talking too quickly, which added to her confusion.

Fortunately, Ms. Luck brought out some gears and building toys for us to play around with. Lily was able to fiddle around with them, and I was able to use them as props for explaining ideas. At the end of the lesson, we did not have a design but I think that Lily had a better grasp on what is needed for the event.

Reflection

Even though I'm trying not to do too many presentations, I'm quite happy with my decision to make the mousetrap car and cable climber presentation. At the previous meeting with Jen, explaining concepts was difficult because Jen had never seen a mousetrap car and was not quite grasping how to use a mousetrap as an energy source. Showing a bunch of pictures of mousetrap cars and cable climbers definitely helped Lily in understanding what was needed.

Despite the presentation, the meeting still would have gone poorly if Ms. Luck had not brought out the gears. I realized during this meeting that, if a person is not familiar with designing mechanical systems, it's much easier to ideate with props rather than imagination or pen and paper. For future meetings, when we're trying to design the cable climber, I'm going to bring as many props as possible to help with ideation.

Something else that I'll be working on in the next meeting is calming down and talking more slowly. I think I was intimidating Lily with my rampant enthusiasm, and that as a result she was more

quiet than she may be otherwise. Hopefully, if I tone it down and if both of them show up to the same meeting, we'll be able to make a working design.

Meeting 4: October 30, 2013

Needham High School

Attendees:

Jen

Meeting Plan:

2. Do Balloon Race activity (Appendix C)
3. Discuss why it worked or did not work
4. Attempt to continue the Bohr's Family Vacation Design

Goals:

1. Understand Balloon Race activity
2. Feel confident in ability to recreate Balloon Race activity
3. Further Bohr's Family Vacation design

Meeting Recap:

Lily emailed me beforehand and let me know that she would not be able to make it, so once again I only had one student. The plan was to go through the Balloon Race activity and then continue the cable car design, but Jen had to leave at 3:15 so we only had a half hour. We were able to successfully complete the balloon race activity, though.

In preparation for the balloon race, I made a worksheet that had all the steps for balloon race: measure the upward force from the balloon, measure the area density of the cardstock, calculate how much cardstock is needed to create an equal but opposite force, and cut an appropriate area of cardstock. I elected to not use it, though, because I figured it would be more memorable if I had Jen figure it out herself. This turned out to be an excellent decision, because then instead of Jen simply following directions she was trying to think of the next step herself.

I started with forces. I asked Jen what she would do to make a balloon rise as slowly as possible; she had the idea of having the balloon string wound around a not quite frictionless spool that unwound slowly. I then asked her what she would do if the balloon could not be attached to something touching the ground. This stumped her a bit so I explained Newton's Third Law, that for a system in equilibrium every action must have an equal and opposite reaction, and if the balloon is exerting a force upwards something must exert a force downwards to keep it from floating away. Throughout much of the conversation she had the apologetic attitude that I get when I talk to a professor about something that I know I learned two years ago but cannot quite remember; she even said that she knew she had learned this sort of thing at some point but could not remember it. Whenever she said this, I assured her that that was fine, and then tried my best to explain the concept as simply as possible.

Once Jen seemed to understand that she needed an equal but opposite force, I asked her what she could use to create the force. She attached the balloon to her purse, which was definitely heavy enough; we then tried my pen, and it was just heavy enough. Since we were using cardstock as our counterweight, she suggested using the paper in smaller and smaller increments, but I said she only gets one chance to test it.

Since it did not seem like she was going to get to the 'correct' way to do the activity on her own in the amount of time we had left, I suggested measuring the mass of the pen and then the mass of the pen with the balloon and finding the difference, which would give us the upward force of the balloon. We did so, and then found the area density of the cardstock (I again had to walk her through it). We tried to find the area that had the correct mass by rearranging the area density equation ($D_A = M/A$) but

Jen had a bit of trouble with this and I had to walk her through it. Again, she had the attitude that she should know how to do it, and felt dumb for not remembering.

Once we did find the area, Jen measured and cut the cardstock. We attached it to the balloon and it did rise slower than previously, but we were off by about a gram. It was about 3:15 at this point, and Jen had to leave, but before she left I tried to ask her my feedback questions. I first asked if she thought the lesson went well; she responded that I had done a better job of teaching and explaining physics to her than anyone had previously. I asked if she thought it was useful, and if she would be able to repeat the activity in competition, and she said she'd definitely remember and be able to do it in the future.

Since Jen had to leave early, I had some extra time and the end and Ms. Luck took me on a tour around the different science store rooms to see if there was anything useful. We discovered that they do have mineral kits (including HCl for testing), and I'll be using those for the next lesson.

Reflection

There are two changes that I would make if I were to do this lesson again, and one thing that I realized that I should have done sooner. The first is that I should have talked with Jen about sources of error. The second is that I should not have been hovering when Jen was trying to do math. And the thing I should have done sooner is researched the resources available to me.

I realized after Jen had left that this lesson was a perfect opportunity to discuss sources of error. While that's not really a conversation that will be useful to have in regards to the competition, I think that understanding sources of error is important if Jen wants to go into a science career. I've missed the opportunity, but I should have had her think of the possible places where we could have created error, which includes in our measuring (with the scale and rule) and rounding (we did not really pay attention to significant figures).

The second thing I would change if I had the chance is that I would not hover so much over Jen. Attempting to do something she did not quite understand was hard enough, but I think I made it doubly difficult because I was watching her think and write things down. Of course, as Jen was the only student there, the alternative was leaving her alone for the calculations, which is not that much better. I think, if I have future meetings, I'll try to have some other thing to do so that I'm nearby and accessible for helping but not hovering and watching a student's every move.

Finally, after Ms. Luck took me on the tour of the science store rooms, I realized that I had even more resources available for this project than I thought. If I were to do this entire project again, I should ask Ms. Luck to show me around after the first meeting, so that I would have a solid idea of what Needham High School has that I can use. As it is, I now know what they have, and can use it for future lessons. I'm excited for this coming lesson, because I'll be using their rocks and minerals kits.

Meeting 5: November 6, 2013

Needham High School

Attendees:

Lily

Jen

Meeting Plan:

1. Go over rocks and minerals identification strategies. (Appendix D)
2. Make a K'NEX prototype of the Bohr's Family Vacation [BFV] device.

Goals:

4. Girls have an understanding rocks and mineral characteristics.
5. Have a K'NEX prototype of the cable car

Meeting Recap:

I decided to switch the order of activities for the lesson, as Jen had to leave at 3:15 again (as it turns out, she has guitar lessons every Wednesday and will never be able to stay past 3:15). I tried to have them work together with the K'NEX, but they kind of each did their own thing. Once again I found myself feeling pretty much useless.

As Jen had not seen the cable climber slideshow, I put up the slide of the cable climber that I found online. Jen started building the frame for it, and Lily a cable pulley, but they did not really do working with one another. I think they need to do some sort of team bonding activity and figure out how to work together.

Anyway, Jen left at 3:15, after making about half the structure of the device. Lily and I finished it; I think that I was doing most of the ideating, but Lily was participating and very obviously understood what we were doing.

Once we had the K'NEX stuff all figured out, I asked Lily if she wanted to do the mineral ID stuff, and was so enthusiastic about it that I think she felt obligated to say yes. Instead of doing the presentation as a presentation/ lecture, I set out all the minerals and let her handle them as I used the slideshow as a prop for when the samples were not illustrative enough. She seemed to enjoy herself.

Afterwards, I asked Lily if she thought the lesson was useful, and if she thought she'd know anything about minerals for competition; she asked what sort of questions might there be for competition and I said probably Mohs scale questions or simple ID questions. I told her I could also send her more detailed notes on mineral stuff. She also said that it felt good to have a prototype for the BFV device.

I then asked her what she would change, and she said that she does not really like the designing for the cable car and much prefers the memorization sort of things. She said that she enjoyed the mineral section because of that.

Reflection

Since this was Jen and Lily's first meeting together, I should have had them do an activity that they *had* to work together for, not just something that they *should* work together for. However, as neither one is entirely reliable, I could not plan ahead for the eventuality that they would both be at this meeting. If I were to have known beforehand, I would have had them practice for the Humpty Dumpty's Heroes event.

Even with K'NEX, leading design is very difficult; I think I should have gone back to the resources given to us in Design Nature [intro Olin mechanical design course] and attempted to teach how to design, and not just jump into it. As it is, I do not think I really had time for that anyway, unless I had spent every single meeting concentrating on the one event.

The mineral portion went well, but I should have had more interactive questioning parts. Those parts would include questions such as “why are you saying this is a mineral and not a rock?” and “how would you describe the luster of this crystal?”. If I had had those questions, I would have been less inclined to just spew facts at Lily.

Meeting 6: November 20, 2013

Needham High School

Attendees:

Lily

Meeting Plan:

3. Play the All About the Atom trivia game (Appendices E and F)

Goals:

6. Girls have some knowledge of Bohr's life and other topics covered in the All About the Atom event.

Meeting Recap:

I had made a game for the previous meeting that I edited for this meeting. As neither Lily nor Jen attended the November 13th meeting, I was able to refine the game. In the end, I had a game board and eighteen questions for each of the topics covered in the All About the Atom event (atomic structure, historic atomic models, electromagnetic structure, the periodic table, nuclear chemistry, the life and times of Niels Bohr). The board looked like generic atomic planetary model, with steps along the electron orbitals for gameplay. The gameplay itself is the same as Trivial Pursuit:

- a single person moves around the board according to the roll of the dice
- after rolling, the person lands on a certain color (denoting a topic) and is asked a question on that topic.
- if the person gets the question wrong, their turn is over. If the person gets the question right, they roll again.
- if the person answers a question while on a 'headquarters' space, they complete the category of that headquarter.
- once a single person completes the headquarters of all categories, they win.

Since my version had fewer spaces than a traditional Trivial Pursuit game, and because I was unable to acquire a die, we used two quarters for rolling, and were able to roll a 1 to 4 (the quarters were distinguishable from each other). We had a few mistakes in rolling (mistaking one of the tails for a different one) but overall the game ran smoothly.

The one way that our game played very differently from Trivial Pursuit was in the answering of questions. In Trivial Pursuit, if someone does not know the answer to a question, they cannot get it right. In our game, we played with clues, so if I or Lily did not know the answer then the other one of us would give clues and try to lead to the answer. As the point was to learn the trivia, and not win, this was a fair compromise.

In the end, it was a very close game by Lily won by one category. It was the sort of win where it was close enough that either of us could have won, and she just happened to be the one. I definitely did not let her win, which was nice.

Reflection

The game went over really well, and it was worth all of the time that I put into it. I'm a bit glad that no one showed up for the previous week, because the game was not at the level that it was for this week, and I put to very good use the extra time that I had to prepare. In the first week, the questions

were almost exclusively about the life and times of Niels Bohr. With the extra week, I was able to write an additional sixty-eight questions covering all of the topics. I was also about to print them on colored cardstock that matched the game board.

As the competition has not happened yet, I'm not sure how well this game will be for preparing Lily. I tried to cover as much as possible of the trivia as I could think of, but I do not feel confident at all that I hit the right questions. I think if Lily has one more play with this game she might have a chance in the All About the Atom event.

Meeting 7: December 4, 2013

Needham High School

Attendees:

Lily

Meeting Plan:

4. Make a sketch model of the BFV device

Goals:

7. We have a sketch model of the BFV device

Meeting Recap:

For this meeting, I brought a bunch of sketch model materials, including pipe cleaners, foam core, tape, and straws. I also brought X-acto knives and cutting boards.

We took the K'NEX model made in a previous meeting and tried to imagine it made of wood, with the foam core acting as the wood. I really had to guide Lily in this; she had a hard time translating the pole and connection type of construction to a flat plane type of construction. She also had some trouble using the X-acto knife to cut the foam core, and in the end she was measuring and I was cutting.

By the end, we had a good idea of what the device would look like, and had an idea of how to build it. We decided to meet on Saturday to build it. Before that meeting, I'm going to get the materials and cut them according to the measurements made today, so that all we have to do is drill holes and assemble it on Saturday.

Reflection

Again, I'm very uncertain on how I feel about how much I'm doing for the BFV device and how much Lily is doing. I feel like I'm doing most of the work (during this meeting, I would suggest a panel and just ask her what the dimensions should be). This is not fair to Lily nor to the other girls of the competition, but if we're going to have a working device I'm not sure what else I can do.

Meeting 8: December 7, 2013

Olin College

Attendees:

Lily

Meeting Plan:

5. Make a the BFV device

Goals:

8. We have a finished and working BFV device

Meeting Recap:

Before this meeting, I was going to have cut all the wood and acrylic into the properly sized pieces so that all Lily and I would have to do was assemble it. Unfortunately, as with the best laid plans, things went awry. When Lily showed up, I had just organized all of the necessary materials and had not cut or measured anything.

Fortunately, this meant that Lily was able to do more, but she only had an hour and a half. She measured the wood, and then we went into the mini wood shop at Olin and I cut it using the vertical band saw. I think Lily was very impressed by the different machines that we could use.

At the end of the time that Lily could stay, we had everything cut but nothing assembled. I told her that I would finish it up for the next meeting, and proceeded to finish it 90% of the way.

Reflection

It was awesome having Lily at Olin and showing her what facilities we have at the school. However, I feel very uncomfortable about the fact that I'm assembling the entire device. The real moment of clarity was when an Olin first year asked me what I was doing. I told him about my project, and how Lily did not have time to do it on her own so I was finishing it for her. He remarked that that was rather sketchy and immoral. At this point I had the box assembled and a spool attached to the top.

I decided then to stop working on the device, and at the next (and last) Wednesday meeting to talk to Lily and give a sort of ultimatum: that Lily is present to finish the device with me or we do not compete in the event. Otherwise it feels just a little too sketchy.

Meeting 9: December 11, 2013

Needham High School

Attendees:

Lily

Meeting Plan:

6. Talk about competition
7. Talk about Bohr's Family Vacation device
8. Play the All About the Atom trivia game (Appendices E and F)

Goals:

9. Know what we're doing at competition
10. Know the All About the Atom trivia questions

Meeting Recap:

For this last Wednesday meeting, we had a few important decisions to make. The BFV device was not in a state where we could test it, and we only had one reliable competitor (given that I had not seen Jen in a month, I did not think she was going to show up, and neither Ms. Luck nor Lily thought otherwise). As I saw it, we had a few options:

1. Attempt to recruit a few girls to compete with a full team
2. Compete with only Lily, and not compete in the BFV event because our device was not functional.
3. Meet on Friday and try to finish the BFV, and then compete in all events with only Lily.

I talked to Lily about the options, and she chose the third. We decided to meet on Friday, the day before competition, to finish the device and try to test it.

Once that decision had been made, we played the trivia game that I had made. I think playing was even more fun than the previous time, because I had not *just* made the cards, so I did not remember all of the answers to the questions. Playing the game a second time also seemed very useful for Lily, because she could then reinforce her memory, and have a better chance of remembering the trivia.

As it was, however, we took a lot longer to finish the game. It may have been that we were extremely unlucky in our dice rolls, or that we had a stronger grasp of the game dynamics and did not accidentally cheat to our advantage, but we ended up declaring the person to get the third category the winner. Because of this, Lily ended up winning again.

Reflection

I was surprised by Lily's decision to try to make the BFV device work, rather than to just write it off. I think part of me was hoping that we would just give up on that event, because it seemed increasingly clear that the device was not going to work, and we only had time to improve it and not begin anew. I did my best not to let that show, and I think Lily saw me as an impartial observer who would support whatever decision she made.

The game was just as fun the second time around, and I think it definitely will help Lily with the All About the Atom event, if I am right about the types of questions they're going to ask.

Meeting 10: December 13, 2013

Olin College

Attendees:

Lily

Meeting Plan:

9. Make the Bohr's Family Vacation device work.

Goals:

11. Have a functioning Bohr's Family Vacation device.

Meeting Recap:

I picked Lily up from Needham High School after school got out, and we drove over to Olin. At this point, the device was fully constructed but needed a longer lever arm on the mousetrap and a method of fastening down the lid. If we had extra time, we were going to add pulleys to make easy the path of the string attached to the mousetrap.

We started out with the longer lever arm. Lily figured out that we needed the arm to be about 15 cm long to stay within the 40 cm height constraint. She measured it and I cut it in the machine shop. I then drilled a hole in the end, to make it easier to attach a hook for the fishing line. Neither of us had a good idea of how to attach the lever arm to the mousetrap, so we looked it up online.

The website we looked at (Doc Fizzix) listed three different ways. Lily and I agreed that we did not want to alter the mousetrap in any way (as we were not entirely certain that it was within the rules). That decision narrowed our choice down to one: zip tie the lever arm to the mousetrap. I acquired two zip ties and Lily tightened them down. Lily then bent one of the wire bits from the mousetrap into a hook, and hot glued it into the hole at the end of the lever arm.

The next thing we had to do was figure out how fasten down the lid. In the previous meeting, we had decided to use a buckle, like from a backpack, but I was not able to easily find one so that idea was no longer possible. After a few minutes of deliberation, we decided to attach eye hooks to the side of the device and tie fishing line loops around the lid. I drilled the holes for the eye hooks, but Lily screwed them in and tied the fishing line. This method worked perfectly, but was a bit difficult to undo and redo.

Finally, we tested it a few times. It did not work very well, but we could not tell if it was a flaw inherent in the design or a result of the cable not having enough tension. We tried to improve the spool the wire rests on by making a hot glue track for the cable to follow, but I'm not sure if that did any good. Regardless, we decided that the device was good enough, and we'd try it the next day at competition.

Reflection

This meeting was a last attempt to make the Bohr's Family Vacation device work before competition. I was slightly unprepared (I was not able to find the backpack buckles) but we were able to easily work around that. I think it was better that I did not have the buckles, because Lily and I then had to think of an alternative method.

In a difference from every other time I worked with Lily on the device, this time I felt like we were working like a team, rather than me leading her and thinking of a lot of the design work. Lily was really excited about doing things herself (bending the wire into a hook, screwing in the eye hooks, hot gluing the track on the spool) and did not seem stressed like she did in previous meetings when she was

trying to fabricate things. Lily was also using her phone less and seemed much more absorbed in the project. However, I'm not sure if that change in attitude was because of anything that I did or because the competition was the next day, and she wanted to have something to compete with.

Overall, I would not change anything about this meeting. Lily got to see the machine shops a second time and was able to make the device kind of work. By the end of the meeting she knew how to set up the device and even had some suggestions on how to improve it, if we had more time. Though we did not know at the time whether or not the device would work, I think we achieved the meeting goal as well as we could.

Overall Reflection

The biggest thing that I struggled with throughout this project was the divide between coaching and doing the work myself. This is also a theme that is common in classrooms, especially science classrooms. A teacher wants his or her students to feel ownership over a project, but also desire the project to be rigorous and scientifically accurate, qualities that are not necessarily feasible if a student is doing all of the work. Is it better then to guide them with a heavy hand, and lead them to the correct answers, or to let them flounder along alone without certainty that they'll end up in the right place?

Unfortunately, I chose the latter path for the BFV device. I had an idea of what could work and heavily influenced the design to follow that idea. As a result, I did the majority of the construction, the device did not work, and I do not think Lily felt ownership over the project. In the book More Best Practices for High School Classrooms, each of the science narratives enforces the same idea: students learn better when in charge of their learning. Lily would have definitely learned more had I structured the lessons to allow her to design and prototype the BFV device.

I think the reason why I so aggressively led the BFV design activities was that I lost sight of what goals I was striving towards. In the beginning, my goal was to teach Lily some really interesting things and then hopefully use that knowledge for the competition. By the end, I think I switched to trying to win the competition. My lessons were then less focused on Lily and more focused on finishing the device at all costs, regardless of the morality of a college student doing the work for a high school competition.

A second thing I struggled with during this project was timing. At the beginning of the semester, I laid out a plan that included equal opportunities for preparing for each event. I stuck with this plan through the first two lessons, but lost it when I realized that the BFV event would take much more time than I had allotted. If I were to redo this entire project, I would try to stick with the plan that I originally made, and modify my methods for BFV preparation so that it fit in the original schedule.

Competition was on December 14th. When we got to the school, they had testing areas for the BFV event, and in using those we quickly realized that our device was vastly over-engineered. I consider that my fault entirely, as I was aggressively leading Lily towards that final design. Lily decided not to compete in both the Bohr's Family Vacation event and the Humpty Dumpty's Heroes event, because she was alone. She did compete in the All About the Atom and the Anything Goes events. She got 29/29 in Anything Goes and 23/29 in All About the Atom. I'm very impressed by that; as a single person competing against three-person teams, she beat six other teams in the event we prepared most for.

On the Wednesday following competition, we met up for a wrap up meeting. I made brownies and we talked about how the competition and year went. Lily had an overall positive feeling about everything. She enjoyed competition, even though it was just her, though she thinks everything would have gone smoother with more people. At competition, she ran out of time while doing the All About the Atom event, and guessed or wrote "I do not know what I'm doing" for half of the Anything Goes stations. She did say that the All About the Atom game I made helped, though there was more math in that event than we expected.

If I were to coach for this competition again next year, I would change a lot of things:

1. I would add more math and less trivia to the event replacing All About the Atom. I would keep the game, however, as it proved to be quite useful.
2. I would recruit earlier and more aggressively, possibly trying to match my meetings up with those of the Needham High School Science Club's to make it easier for girls to participate.
3. I would do actual preparation for the Humpty Dumpty's Heroes event, a thing which was nearly impossible this year because I only ever had one girl at a meeting.

4. Instead of trying to lead the design for the building event, I would give the girls a ton of materials and K'NEX and treat it like an instant engineering event. We would take the devices they make and refine them for competition.

5. I would be broader in my attempts to prepare for Anything Goes. The event included things like tidal charts and muscular anatomy, which I had not even thought of preparing for. Though it's certainly impossible to exhaustively prepare for this event, I could certainly do a better job.

I think that, if I made those changes, Lily (and possible two more girls) would have been much more competitive.