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| Study Group | STeLLA Study Group |
| Video ID | Jody SG1 (Study Group Video ID BSCSCPPSTudyGrp\_1\_3\_clip2; Classroom Video ID mspcp\_gr3.forces\_wilde\_l5\_c10) |
| Content Area | Grade 3: Forces |
| Teachers | Brandy Fowler (BF), Kris Lathon (KL), Tricia Torres (TT), Susan Marie Farman (SF), Kathy Griffin (KG), Arise Wilde (AW), PD Leader Jody Bintz (PDL) |
| Context | Teachers in this clip are part of a STeLLA study group. They are analyzing lessons and classroom video from a 3rd grade classroom studying forces. Teachers have watched the video and engaged in the Identify and Analysis Phase of the Lesson Analysis Protocol. During the Analysis Phase, the PDL decided to move into a content deepening conversation. She invited study group members to represent the forces acting on a ball being thrown from the time the ball is behind the head to just after it’s released.  |

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| 00:00 | PDL | 1 | Okay. I want you to look at these representations and see if you can identify some similarities and differences. |
| 00:16 | BF | 2 | Oh, these two look a lot alike, they're just going in opposite directions. |
| 00:19 | KL | 3 | Mm-hm. |
| 00:20 | PDL | 4 | Can you des- can you- can you point? |
| 00:22 | BF | 5 | So- well, that one's mine, I'm not sure whose this one is- |
| 00:24 | TT | 6 | That's mine. |
| 00:25 | BF | 7 | We pretty much got the same idea going with the whole throwing of the ball, momentum's pushing it this way, wind's taking it that way, and gravity's pulling it down. |
| 00:42 | KG | 8 | I have lots of arrows and other people have one, which- |
| 00:45 | KL | 9 | I have a lot of arrows too. You just can't see them very well. |
| 00:50 | SF | 10 | I just didn't label mine. |
| 00:55 | AF | 11 | Sorry, I thought it was for our own understanding, so I didn't label mine, sorry. |
| 00:58 | PDL | 12 | Yeah, I should've- I should've made that- I sh- I- I- I didn't know what I was doing. |
| 01:02 | SF | 13 | Didn't know we were being graded. |
| 01:03 | PDL | 14 | Yeah, I did- yeah, and I didn't make that visible. So let's use these two for just a minute.  |
| 01:10 | PDL | 15 | Okay, so does everybody agree that when my hand is on the ball, that my- I'm putting- applying a force on the ball? |
| 01:22 | Many/ PDL | 16 | Yes. / Does everybody agree on that? |
| 01:23 | Many | 17 | Yes. |
| 01:24 | PDL | 18 | Does everybody agree that gravity is always acting down on the ball, whether it's in my hand or not? |
| 01:31 | Many | 19 | Yes. |
| 01:32 | PDL | 20 | Do we all agree on that? |
| 01:33 | Many | 21 | Yes. |
| 01:34 | PDL | 22 | Does anybody's representation not show those two things? I- whether you thought it or not, does anybody's representation not show those two things? |
| 01:44 | KL | 23 | I don't have- |
| 01:45 | PDL | 24 | Air resistance and gravity? |
| 01:47 | KG/KL | 25 | I don't have the top one. / (Inaudible) I didn't put air resistance. I was focused on the hand and the ball. |
| 01:53 | PDL | 26 | Okay. If you were going to put in- so- so if you were going to put in air resistance, can you grab a pen and, like, show what that might like look on yours? |
| 02:07 | KL | 27 | I think this would be the strongest. And then it would gradually release.  |
| 02:23 | PDL | 28 | So you were making a connection between strength and gradual release. Why- why were you saying that? |
| 02:36 | KL | 29 | Um. Momentum. |
| 02:44 | PDL | 30 | Okay. |
| 02:45 | KL | 31 | Momentum and… |
| 02:52 | KL | 32 | Because the strength- the biggest momentum starts from the windup in the back. So- |
| 02:59 | PDL | 33 | Okay. |
| 03:00 | KL | 34 | as I- as I'm pushing, pushing, pushing, pushing, and then release, but the minute I release that, that momentum has been taken away. |
| 03:10 | PDL | 35 | So can you say what momentum is? That's kind of a new word. And I saw several people refer to momentum. What- what is momentum? |
| 03:20 | KL | 36 | Consistency of force? Building of force? |
| 03:23 | BF | 37 | Force acting upon something? |
| 03:25 | PDL | 38 | Force- so are you saying force and momentum are the same thing? |
| 03:30 | BF | 39 | I think momentum is an effect. The product of force. |
| 03:39 | PDL/BF | 40 | Inter- okay. / So you're adding the force by throwing it. The momentum is what the ball's doing when you rel… |
| 03:46 | PDL | 41 | What do others think? About what is momentum? I mean, you've all said forces are pushes or pulls, but- but what about momentum? |
| 03:54 | KG | 42 | Momentum is the initial push that happens, and then that decreases, that effect decreases as gravity works on it and as air resistance goes against it. |
| 04:08 | PDL | 43 | Do other agree or disagree? |
| 04:12 | TT | 44 | I'm kind of thinking of momentum as speed. |
| 04:16 | KL | 45 | Mm-hm. |
| 04:17 | PDL | 46 | So you're making a connection between momentum and speed? |
| 04:21 | TT | 47 | Kind of. I mean, in the way that we're describing it, it's the- almost the- we can see the effect in the speed of the ball, but the momentum is the- the amount of energy- |
| 04:35 | KL | 48 | Mm-hm. |
| 04:36 | TT | 49 | that the ball is- I don't know. |
| 04:39 | KL | 50 | Only because if I- so momentum being that if I wind up and really actually make it to the target, if my momentum, I can either try and literally throw it across the room with a whole lot of momentum, |
| 05:00 | KL | 51 | but my momentum is intentional, it versus that.  |
| 05:06 | PDL | 52 | Ah. |
| 05:07 | KL | 53 | So, depending on how far I want it to go, I'm going to determine how much momentum I'm going to need to get it to where it needs to be. |
| 05:17 | PDL | 54 | Okay. So I’m going to give you just a little bit more information- |
| 05:21 | KL | 55 | Like getting in the barrel when you want to get the ball in the- when you're playing golf and putting. |
| 05:27 | PDL | 56 | There you go. |
| 05:28 | KL | 57 | How much momentum do I need behind the club to get either just a little bit or a really long way? |
| 05:35 | PDL | 58 | So we're going to start with just a- a pretty straightforward definition of momentum, because you've got some ideas that are really consistent with that. |
| 05:45 | PDL | 59 | And then we're going to try to reconnect those then back to what's the relationship now between momentum and force? |
| 05:52 | PDL | 60 | So, momentum…is the product, which I thought was interesting, 'cause somebody said product of mass times velocity. |
| 06:09 | BF | 61 | Okay? |
| 06:12 | KL | 62 | So I'm going to have less momentum with a bigger object, because it has more mass? |
| 06:18 | Many | 63 | More mass.  |
| 06:20 | AW | 64 | Or you'd have more. |
| 06:21 | TT | 65 | Not necessarily. |
| 06:23 | KG | 66 | Oh, oh- |
| 06:24 | TT | 67 | Because you're multiplying, so if you have a larger mass, you're going to have a larger ultimate momentum if you have the same velocity. |
| 06:33 | KG | 68 | Mm. But wouldn't the bigger an object, the more mass it has, the less velocity I'm going to be able to throw it with? |
| 06:40 | PDL | 69 | Now you're connecting momentum and force. |
| 06:43 | KG | 70 | Okay. |
| 06:44 | PDL | 71 | Right? So you're starting to make that leap. |
| 06:46 | BF/ PDL | 72 | Mm-hm. / Awesome! Because that shows what we want to be able to do, right?  |
| 06:51 | PDL | 73 | So let's start just with momentum first, okay. Does it make sense that the greater the mass, the greater the momentum? If the velocity remains constant. |
| 07:02 | BF | 74 | Mm-hm. |
| 07:03 | PDL | 75 | That's what Trish said. Now, flip it around. What happens if you have greater velocity? The same mass. What- what's that going to do to the momentum? |
| 07:15 | Many | 76 | Increase it. |
| 07:17 | PDL | 77 | Increase it, right? So you get that product, right? So now let's just intuitively make that connection to force.  |
| 07:24 | PDL | 78 | If I have a very massive object- notice I'm not using “big” or “little” now, I'm saying the quantity that I'm talking about, right? |
| 07:32 | KG/ PDL | 79 | Mm-hm. / I have a massive ob- object. And I want to get that object going at a higher velocity. |
| 07:41 | BF | 80 | Mm-hm. |
| 07:42 | PDL | 81 | Talk to me about the force. |
| 07:44 | NF | 82 | You need greater force. |
| 07:47 | PDL | 83 | Why? |
| 07:50 | AW | 84 | First you have to make it move in the first place. If it's a huge mass, it's going to be hard to move. So you're going to need to apply a really big force to it. |
| 07:59 | PDL | 85 | Okay. As opposed to an object that is less- has less mass? |
| 08:04 | AW | 86 | Mm-hm. |
| 08:06 | PDL/AW | 87 | Does that make sense? / Mm-hm. |
| 08:07 | PDL | 88 | Okay. |