Authors

Erica Chemtob ● Sarah Schrup ● Logan Bartholomew ● Yan Kai ● Jasmina Abdalla ● Jackie Veatch

Physics Talk Moves Guide

December 2017

What are the Nine Talk Moves?

The Nine Talk Moves which were originally developed by the Inquiry Project[1] are a guide to teaching. They fall under four main goals: Help Students Share, Expand and Clarify Their Own Thinking, Help Students Listen Carefully to One Another, Help Students Deepen Their Reasoning and Help Students Think With Others. Talk Moves can be best implemented to facilitate meaningful, constructive conversations in STEM classrooms.

We have adapted and expanded upon the pre-established Talk Moves to better fit the Introductory Physics courses taught here at GW. The SCALE-UP format requires a large amount of in-class, collaborate problem solving. We have formulated talk moves to help new LA's in this classroom environment. We have also added a fifth goal to the Talk Moves: Help Students Develop Problem Solving Skills in Physics, which we believe is especially applicable to Physics LAs.

For Future LA's:

We have used our knowledge from Pedagogy with Dr. Sikorski to create a list of physics-specific Talk Moves to help guide you through your experience as a new LA.

Goal One: Help Students Share, Expand and Clarify Their Own Thinking: Gauge the Group

"Physics students often approach problems in a variety of ways ranging from applying previously learned concepts to newly introduced topics (such as using kinematic motion to describe angular velocity and acceleration) to scrambling through equations from a handout to referencing previous problems or in-class examples. It is important to preemptively understand how a group initially attempts to grasp a problem or concept; we can use this information to both allow the group to build upon their own group dynamics and to modulate how we begin to analyze and eventually facilitate group discussion."

Talk Move 1: Time to Think

This can include: Partner Talk, Writing as Think Time and Wait Time[1]

Here, we think it is good to gauge what students are already thinking about a concept. Sometimes, students will attempt to approach a problem with already developed concepts; some will use kinematics or Newton's laws to approach problems involving torque or wave dynamics which *can* be sound; it is oftentimes beneficial to allow students to extrapolate and form an idea of how some concepts can be understood. It is better for them to realize their own mistakes and then work to solve them than for the LA to point it out (in terms of understanding development, at least) because making and realizing a mistake in itself are both displays and developments of understanding.

We can use a student group's preliminary work to shape how we will approach orientating group work. Without them knowing it, from a quick look at their arithmetic and the equations their heuristic ideas make them *want* to use, we can determine which concepts we will use to drill and challenge the students. For example, seeing students using linear kinematics for rotational motion could be met with "what's another way we can define velocity in circular motion" or "what values remain constant during uniform circular motion" (prompting them to use angular velocity and realize the relationship between linear velocity and radial distance).

Talk Move 2: Say More[1]

"Can you say more about that?"[1]

Lots of the concepts in physics rely on a very basal understanding of the introductory concepts such as Newton's second law or the derivative relationships between position, velocity, and acceleration versus time. We will often ask students to look for the fundamental constituents in a concept or help them to understand how all of the topics of the class correlate.

This helps answer the question “when will I ever use this?” or “why do we need to learn this?” because, unlike some other courses’ concepts and core ideas, the relationships here are incredibly blatant; it’s hard to miss how the kinematic equations might apply to the ideas of force or impulse and how they can be utilized even with electromagnetism, for example.

“What do you mean by that?”[1]

We’ve noticed a general trend with our students’ multiple understandings of given concepts (most notably with acceleration and impulse); there are a *lot* of ways to define these. One of our TAs, Maria, even pointed out that impulse doesn’t exist in her language.

It’s essential to get students on at least a similar wavelength; it’s impossible to teach *all* of the students in the same way *but* it is very possible to get them to the same conceptual understanding even if the modalities differ. I will often ask students to explain their ideas in terms of previously understood concepts and use their explanations to gauge the dynamic efficiency of the group they are working in.

“Can you give me an example?”[1]

This ties well into the previous two by combining them, in essence; we ask students to point out other physical ideas they used to come to the conclusions they do. Physics is best understood by using concepts already solidified; examples, then, are often useful for more basal explanations of the key concepts of a problem. Asking “how could you see us using this in the future” and “what do you think we are doing this for?” usually helps students realize these connections. We’ve been reliably informed this helps them to approach quizzes holistically rather than with tunnel vision.

“How did you determine which equation to use?”

Example: In a situation where students are facing a problem that may have many applicable equations associated with it, an LA could say “Why did you choose the kinematics equation involving velocity and time, but not the one involving distance?” This is a good question to ask, especially related to the physics kinematics equations, since students have trouble determining which variables they need to solve for, and therefore which equation to choose.

Talk Move 3: “So, let me see if I’ve got what you’re saying. Are you saying…?”[1]

Always leave space for the original student to agree or disagree and say more

As we see in the second talk move, students can understand things in a *lot* of different ways (and sometime will have flaws in their understanding based upon flawed epistemologies or usage of flawed heuristics developed from other concepts).

We can pose students' interpretations to them in terms of the fundamental concepts discussed prior; this allows us to ensure a sound understanding of the core material while allowing students to see the extrapolative measures used to arrive at the new material.

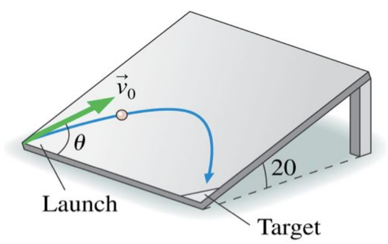
Or, we can summarize and refine students' ideas indirectly while integrating the objective concepts of the ideas being discussed; this allows us to subtly interject the correct concepts into a student's already developed ideas.

Example Problem:

Oftentimes, students have difficulties deciding which kinematic equation to use when facing a complex motion problem. In this scenario, which talk moves might be helpful?

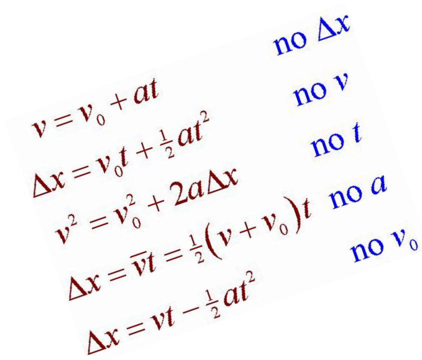
In a contest at the county fair, a spring-loaded plunger launches a ball at an initial speed of $v_0 = 3$ m/s from one corner of a smooth board that is tilted up at a 20° angle. To win a prize, you must make the ball hit a target at the adjacent corner 2.5 m away.

At what angle θ should you aim the launcher?



We suggest:

"How did you determine which equation to use?" and "Can you say more about why that equation would help?". Feel free to make your own talk move as well! For example, "Which equation contains variables applicable to this question?"



<u>Goal Two</u>: Help Students Listen Carefully to One Another: Help Them Help Each Other

"Once a group's preliminary ideas are understood, it is important to facilitate the intermingling of these ideas. Research shows that giving an explanation on a given topic not only adds to group discussion but, more importantly, causes the most understanding and learning for a given student. Equity is important here; each student should either give an explanation of his or her ideas or build upon another student's idea with his or her own interpretation. This allows students to collectively and equitably approach a solution or begin to understand a problem by employing high-level reasoning and problem solving skills."

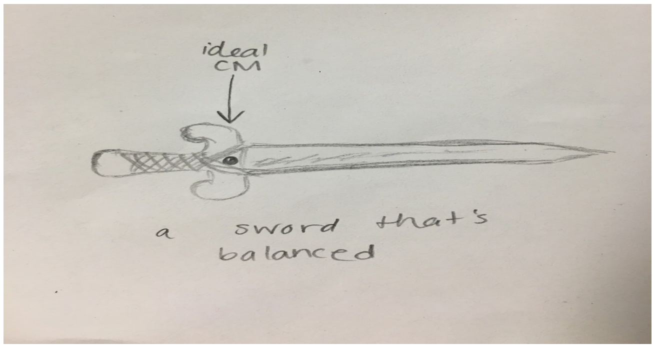
Talk Move 1: Rephrase or Repeat

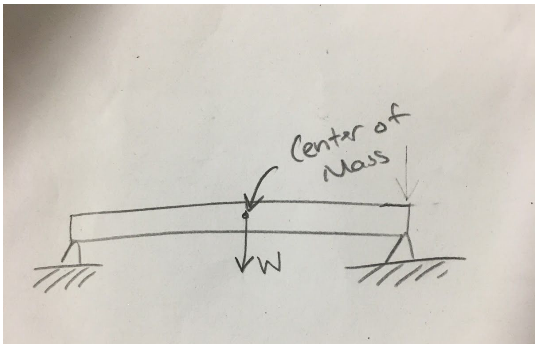
"Who Can Rephrase or Repeat?"[1]

It is important that students are able to explain things in their own words. Research supports that students who do more of the talking or explaining are learning more[2]. This Talk Move facilitates this, and also ensures that students are listening to each other.

"Who can draw what [student] just said in a diagram or picture?"

In our Pedagogy course, we learned about the importance of being able to draw or write down concepts. In Richard Feynman's article, "What Is Science," he discusses how this ability demonstrates a greater understanding of the material[3]. For one Field Note assignment, we asked students to draw a relevant physics concept for us. From this, we found differences in students' understanding of the material. In some cases, this helped us to clarify the concepts with them. The drawings below were from the "Center of Mass" lectures in General Physics I class. They both demonstrate a firm understandings of the center of mass.



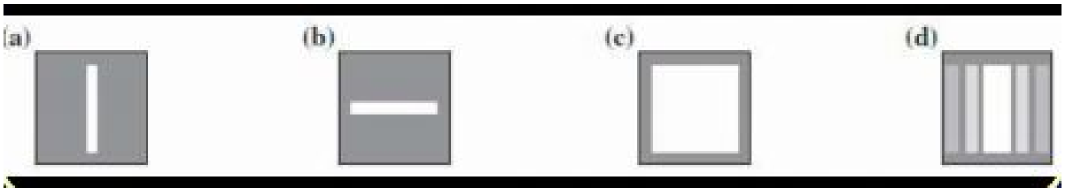


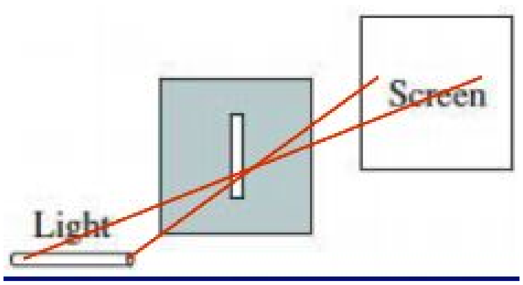
Talk Move 3: Relating to Past Coursework

"Can anyone relate what [student] just said to an overarching concept in this class?"

This Talk Move serves a few purposes. First of all, it could bring attention to what a student was saying, since sometimes we notice that other students are not listening to their peers. Also, this will allow the students to relate a specific example or solution to the lecture topic or an even broader concept. This "broad-picture" thinking is especially important in physics, as it will help students to be able to look at unfamiliar problems or new concepts and be able to relate it to something they've learned, and connect the dots.

Introductory Physics II students may see a question like the following: A long, thin light bulb illuminates a vertical aperture. Which pattern of light do you see on a viewing screen behind the aperture?





Answer: C

Explanation: The up and down part is defined by the slit, it blocks rays that strike above and below the slit. The sideways illumination comes from rays emanating from the left and right side of the bulb as visible in the below picture. What talk move might be useful to help a group of students work together to reach a solution? We would suggest asking one student to "draw what Student A just said". Not only does this build teamwork, but it asks students to interpret other's ideas, furthering communicative skills.

Goal Three: Help students Deepen Their Reasoning: Facilitate Further Learning

"The fundamental concepts of physics appear time and again amongst the expansive curriculum herein; it is important to point out the connections between topics as well as help students to solidify their understanding (or highlight conceptual flaws) of newly introduced material and basal concepts alike. Challenging students to "think outside the box" or further apply their knowledge accentuates group dynamics as well by promoting discussion and equitably solicits ideas."

Talk Move 1: Asking for Evidence or Reasoning

"Why do you think that?"[1]
"What's your evidence?"[1]
"How did you arrive at that conclusion?"[1]
"Can you walk me through your reasoning?"
"How would you explain this to someone who knew nothing about physics?"'
"How did you determine which equation to use?"

Example: In a situation where students are facing a problem that may have many applicable equations associated with it, an LA could say "Why did you choose the kinematics equation involving velocity and time, but not the one involving distance?" This is a good question to ask, especially related to the physics kinematics equations, since students have trouble determining which variables they need to solve for, and therefore which equation to choose.

Talk Move 2: Responding to "Is this right?"

"I don't know. Can I see your reasoning?"
"Can you say more about the forces drawn in your free body diagram?"
"(Looking at their solution) Which part are you not sure about?"

Talk Move 3: Challenge or Counterexample

"Does it always work that way?"[1]
"How does that idea square with [student]'s example?"[1]

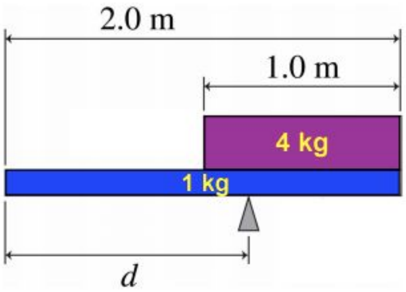
"What if it had been a copper tube instead?"[1]
"Why is this different compared to the other problem?"

We have noticed that many students try to apply the same reasoning from one problem that they already solved to a new problem that seems similar, but in fact it is not. If you can recognize this happening in the classroom, it may be helpful to point out why the two problems are different and how those differences impact the problem solving process. Using past experience can be helpful, but oftentimes it is useful to share with students that past experience with problems should be used as reference, not as a guide for all problems.

Talk Move 4: Compare with other knowledge

"What would happen if ...?"
"Is the answer what you thought it would be?"
"Do your units make sense?"
"Can you test your answer using a limiting case?"
"Does your number make sense given your knowledge about this scenario in the real world or other famous numbers in physics?"

Example Problem:



For example, in the image, students would be asked to find distance d. One great talk move to use when students get an answer is "Does your number makes sense given your knowledge about this scenario?" This is a multipurpose talk move.
First, if students get a number larger than two, or something crazy like 400, then they can be checked in this way.
Second, they know based on the scenario that the sides must be balanced, so by using that informal reasoning, they can know that d must be larger than ½ of the total length

Goal Four: Help Students Think With Others: Enhance Collective Thinking

"Giving explanations and the resultant conversation in an equitable group in conjunction with the expert problem solving strategy of equal consideration of ideas promotes an excellent learning environment. Physical concepts encompass a wide range of nuances and different epistemological stances; we can help students to "fill out" their conceptual understandings by introducing different pathologies to understand new ideas."

Talk Move 1: Agree/Disagree and Why?[1]

"Do you agree/disagree? (and why)?"[1]
"What do people think about what [student] said?"[1]
"Does anyone want to respond to that idea?"[1]

Talk Move 2: Add On[1]

"Who can add onto the idea that [student] is building?"[1]
"Can anyone take that suggestion and push it a little further?"[1]
"Where do you think we can go next?"

Talk Move 3: Explaining What Someone Else Means[1]

"Who can explain what [student] means when she says that?"[1]
"Who thinks they could explain why [student] came up with that answer?"[1]
"Why do you think he said that?"[1]

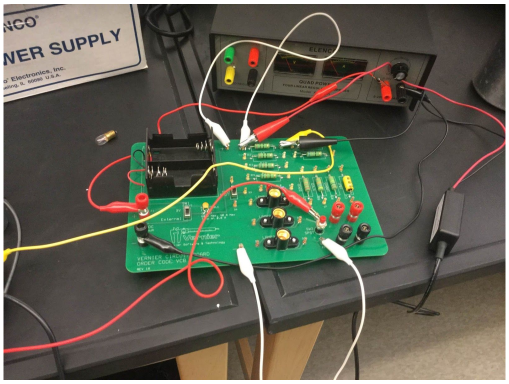
Talk Move 4: Responding when one student is doing most of the work

Suggest having another group member write on the board for the group
"Ok now let's slow down for a minute, can you explain to your groupmates how you got to this step?"

Directing talk moves or questions towards a specific group member "Do you all understand how student A got to this answer?"

In the case that mainly one students was doing the work, it would be important to direct your attention towards the other students to see if they understand how that student solved the problem.

Example Scenario:



Oftentimes in group work, inequitable participation occurs. Inequitable participation is the unequal sharing of work, talk time and idea sharing. LAs work hard to facilitate helpful, constructive conversations that include all group members. Oftentime, this means encouraging students who don't feel ready to speak up, and sometimes asking highly participatory students to take on a listening role.
For example, in lab is a student is working on a circuit board, without speaking to their group members or asking for input, LAs could ask the other students to check the circuit, following it around the board and explaining what is happening to the current, voltage, resistance, etc.

Goal Five: Help Students Develop Problem Solving Skills in Physics

"The vast array of intertwined concepts in physics can be hard to align and even more difficult to apply correctly and efficiently when approaching a problem. We can use heuristic pathways to highlight to fundamental concepts within a problem and concisely approach an answer. This can be done literally by writing out equations or by internally going through a concept map to see the proper path to take when solving a problem."

Talk Move 1: First Steps

"What is the very first thing you would do here?"

Where to start is often a daunting task. Facilitating a discussion where multiple minds are working on answer this question will get the group moving forward.

Talk Move 2: Looking Back

"What about this problem looks similar or different to one's you've seen in the past?"

Oftentimes, students struggle to get started with a problem. This talk moves helps remind them that they may have seen a similar problem before and be able to use that experience as reference.

"How would you relate to this concept that we went over in class?"

Have students recall previous problems and compare what is similar/different about the problem at hand. This way, students can realize what problem solving skills they could use previously, and how they differ from the current problem, what models fit previous problems that do/don't fit the problem at hand. This could help the students think of a connection between the class lecture and the problem at hand, to solidify that material.

Talk Move 3: Next Steps

"What are the next steps you would take?"

Example: Student needs to find the difference in pressure to use the bernoulli equation to solve for the speed at a particular point. "How might you go about solving an equation with two unknowns?" In Physics classrooms, students are oftentimes presented with multi-step problems to solve.

"Where would you look for the next piece to the solution?"
"How can you add to the step your partner just took?"

Looking ahead to further steps in the problem forces the students to think about whether or not their current step is going to lead them towards what they are looking to find.

Talk Move 4: Building on Common Knowledge

"Can you think of any famous laws in Physics that we can start from for this problem?"

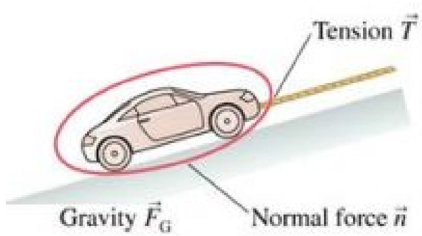
Building upon previous knowledge to start the problem can make a new and challenging problem seem more feasible. For example, in mechanics and E&M classes, concepts build upon one another. Below are concepts in each class that build upon one another. These connections can be very useful for both learning and teaching.

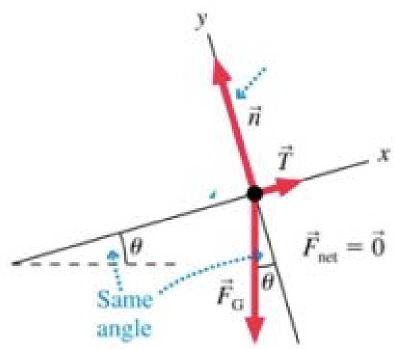
Mechanics: Newton's Laws ❯ Conservation of Momentum ❯ Conservation of Energy

E&M: Ohm's Law, Kirchoff's Law ❯ Maxwell's Equations (Gauss's Law, Ampere's Law Faraday's Law) ❯ Wave equation ❯ Snell's Law

Example problem:

As students learn physics, they add on to previously learned concepts. For example, when looking at the forces acting on a car in the picture below, a student can start with concepts they are already familiar with. Say the class has covered gravity but not normal force, the talk move "Can you think of any famous laws in Physics that we can start from for this problem?" This will help the student label gravity, but if the car is not moving, potentially also think about force balance to realize there must be some upward force opposing gravity.





References:

[1] Chapin, S. O’Connor, C., & Anderson, N. *Classroom Discussions: Using Math Talk to Help Students Learn, Grades 1-6.* Sausalito, CA: Math Solutions Publication, 2009.

[2] Chizhik, Alexander W. *Equity and status in group collaboration: learning through explanation depends on task characteristics.* Netherlands: Kluwer Academic Publishers, 2002.

[3] Feynman, Richard P. *What Is Science?* American Association of Physics Teachers, 7, 313 1969. doi: 10.1119/1.2351388