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Aligning PRISMS Plus with NGSS and Physics Education Research

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Abstract

Since the Next Generation Science Standards (NGSS) have been adopted by Iowa, the changing expectations for high school physics students means that preexisting curricula like PRISMS PLUS need to be brought into alignment with the NGSS. Before revising PRISMS PLUS, other aligned curricula were consulted, as well as many sources of physics education research. A revised PRISMS PLUS template aligned with the NGSS and physics education research was made, which can be applied to each of the learning cycles in PRISMS PLUS. One learning cycle was revised in full, as an example.

PRISMS PLUS NGSS Alignment

PRISMS PLUS (Cooney, et al., 2008), which predates the creation of the Next Generation Science Standards (NGSS), has a series of learning cycles (LC) for each of the four broad units that encompass a high school physics curriculum. Each student LC is comprised of three activities (an exploration, explanation, and elaboration) that engage students with content, as well as a reading section and a series of conceptual questions to support student learning. PRISMS PLUS includes a comprehensive teacher's guide and a set of activities for Constructing Physics Understanding (CPU) simulations Goldberg, 1997).

The NGSS is made of three equal parts: Core Ideas, Science and Engineering Practices, and Crosscutting Concepts (NGSS Lead States 2013). Each of these are considered to have equal importance. Since Iowa has adopted the NGSS, preexisting curricula implemented in classrooms need to be revised to ensure alignment.

Before any revisions were made, PRISMS PLUS was mapped out with the parts of the NGSS, to determine its existing alignment. PRISMS PLUS does well at engaging students with Science and Engineering Practices, as each of its three activities has students doing science.

Two NGSS-aligned curricula were evaluated: Full Option Science System (FOSS) Next Generation middle school physical science curriculum (Lawrence Hall of Science, 2019) and Next Generation Physics and Everyday Thinking (Next Gen PET) curriculum (Goldberg 2018). Evaluating these curricula provided good insights for how to incorporate all three parts of the NGSS into PRISMS PLUS.

Physics Education Research

A summary of the major conclusions of Physics Education research is given by Knight's Five Easy Lessons, which are as follows:

1. Keep students actively engaged and provide rapid feedback
2. Focus on phenomenon rather than abstractions
3. Deal explicitly with alternative conceptions
4. Teach and use explicit problem solving skills and strategies
5. Write homework and exam problems that go beyond symbol manipulation to engage students in the qualitative and conceptual analysis of physical phenomena. (Knight, 2004)

The 5E Learning Cycle (Bybee, 2015) adds a stage before and after the three in PRISMS PLUS, an engagement and an evaluation of student knowledge. These two stages are found in the teacher's guide of PRISMS PLUS, completing the 5E LC.

Models are representations of reality, and come in many forms, including verbal, graphical, and mathematical. The development and use of models in instruction is called a modeling cycle, which places information responsibility on the student. The modeling cycle is compatible with all other LCs. PRISMS PLUS has some aspects of modeling, but no complete modeling cycle.

Formative Assessments are a kind of assessment used before and during instruction to gain knowledge of student understanding for the purpose of targeting instruction to address student preconceptions. PRISMS PLUS has opportunities for formative assessment, though they are not explicit.

Phenomena-based learning is a way of focusing lessons around real-world phenomena. When NGSS Phenomena are used, students learn NGSS Core Ideas and Crosscutting Concepts to explain these phenomenon.

Revised Inertia Cycle

PRISMS PLUS Inertia LC was revised with NGSS and Physics Education research in mind.
Each major revision is the direct result of the changes to the template of a LC. Because the LC is teaching Newton's First Law through the concept of inertia, the LC was renamed to "Newton's First Law". The revised LC teaches students Newton's First Law through three inertia phenomenon, a reading, and a series of conceptual questions.

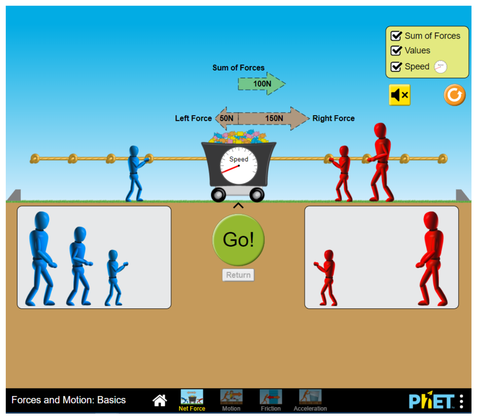

Fig. 1: A screenshot of the PhET simulation Force and Motion: Basics, used in the revised Inertia LC.

Revised Template

An NGSS-aligned template for the PRISMS PLUS LC was produced. This template could be used to revise any LC in PRISMS PLUS. Some of the noteworthy changes reflected in this template include:

- Previous standard replaced with NGSS standard being taught, and Crosscutting Concepts and Science and Engineering Practices given for each LC
- Introduce modeling cycle within the LC
- Adapted activities at every stage of cycle to make formative assessment more explicit
- Replaced unavailable CPU-simulations with the available online PhET Interactive Simulations
- Added 5E LC names to previously unlabeled sections of LC
- Made discussions of phenomena begin and end the LC
- Change the "Problem" question at the start of each activity to a Scientific Question, Engineering Problem, or Focus Question

The final LC of PRISMS PLUS takes the format of the cycle given above, a combination of the 5E (Bybee, 2015) and Formative Assessment (Keeley, 2015) cycles.

Reflection

In the future, the template created could be applied to all LCs of PRISMS PLUS. Some LCs do not teach to any NGSS Core Ideas. These LCs do still have Crosscutting Concepts and Science and Engineering Practices, and should be considered on an individual basis for possible integration with other LCs, revision, or removal. Some NGSS Core Ideas are not taught in PRISMS PLUS. A few LCs could be modified to incorporate a few of the NGSS Core Ideas. For all others, new LCs would need to be drafted.

Being a future high school physics teacher in Iowa, I will need to be able to modify curricula for classroom use, and to be aligned with the state standards. As a result of engaging in summer research and completing this project, I will be able to revise curricula, and improve the understanding of my future students.

Acknowledgements

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References

American Modeling Teachers Association. (2016). Retrieved from https://modelinginstruction.org/
Bybee, R. W. (2015). *The BSCS 5E Instructional Model: Creating Teachable Moments*. Arlington, VA: NSTA Press.
Bybee, R. W. (2013). *Translating the NGSS for Classroom Instruction*. Arlington, VA: NSTA Press.
Cooney, T. M., Escalada, L. T., Unruh, R. D. (2008) *PRISMS PLUS*. Cedar Falls, IA. University of Northern Iowa Physics Department.
EQuIP Rubric for Science. (2016, September). Retrieved from https://www.nextgenscience.org/resources/equip-rubric-science
Goldberg, F., et al. (2018). *Next Generation Physical Science Everyday Thinking*. Greenwich, CT: Activate Learning
Goldberg, F. (1997). Constructing physics understanding in a computer-supported learning environment. *AIP Conference Proceedings*. doi:10.1063/1.53098
Iowa Core. (n.d.). Retrieved from https://iowacore.gov/iowa-core/subject/science
Keeley, P. (2015). *Science Formative Assessment:* (Vol. 1 and Vol. 2). Thousand Oaks, CA: Corwin.
Knight, R. D. (2004). *Five Easy Lessons: Strategies for Successful Physics Teaching*. San Francisco, CA: Addison Wesley.
Lawrence Hall of Science (2019). *Full Option Science System Next Generation*. Nashua, NH: Delta Education.
Lawson, A. E. (2002). *Science Teaching and the Development of Thinking*. Belmont, CA: Wadsworth.
NASA eClips. (n.d.). The 5E Instructional Model (S. Verstynen, Ed.). Retrieved from https://nasaeclips.arc.nasa.gov/teachertoolbox/the5e#collapseOneA eClips. (n.d.). The 5E Instructional Model (S. Verstynen, Ed.). Retrieved from https://nasaeclips.arc.nasa.gov/teachertoolbox/the5e#collapseOne
NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington DC: National Academies Press.
Phenomena for NGSS: Creating the Next Generation of Student Engagement. (n.d.). Retrieved 2019, from https://www.ngssphenomena.com/
PhET. (2019) *PhET Interactive SImulations*. Boulder, CO: University of Colorado. Retrieved from: *https://phet.colorado.edu/en/simulations/category/physics/motion*