**WND2017 MacIsaac Presentation**

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**Abstract: Modeling Physics in the US**

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In 1987, Malcolm Wells, working with Professor David Hestenes at Arizona State University laid the foundations for what became *modeling physics*. Modeling physics currently includes a fully developed year long introductory high school / first year college physics curriculum, characteristic pedagogical innovations such as student centered cooperative whiteboard discourse and the modeling learning cycle, explicit assessment and evaluation practices / instruments, summer professional development modeling workshop courses, and an extended and growing community of US educators dedicated to promulgation of the modeling method and continuous cultivation of teacher expertise. These resources were developed and disseminated with funding from the US National Science Foundation via US national workshops during the 1990’s. Driven by teachers, modeling pedagogy grew to encompass an interest in developing other modeling-physics like curricula in chemistry, middle school and elementary physical science, and biology.

In summer 2017, the American Modeling Teachers’ Association (a professional group of 2,500 teachers and professors) coordinated 54 summer workshops of 3-15 days length hosting about 1,000 teachers across the US, including 24 workshops in physics, 13 in modeling chemistry, 8 in modeling biology, 6 in middle school science and 3 in modeling pedagogy. As of 2017, more than 11,000 teachers have participated on one or more summer modeling workshops and it is claimed that 10% of US physics teachers working at over 60 sites in 49 states had attended a modeling workshop.

Presentation participants will review and actively analyze a video vignette of characteristic classroom student modeling physics practice. I will provide a synoptic overview of modeling physics in terms of content, pedagogy, context, community, research and past and future development, before taking questions and comments.

Dan MacIsaac is *Associate Professor of Physics* at SUNY Buffalo State College in Buffalo NY currently on sabbatical as *Gastwissenschaftler* at the Institut für Physikdidaktik, Universität zu Köln. He has advised more than 200 US high school physics teachers during their masters’ degree studies in physics and physical science pedagogy, and has instructed graduate credit summer modeling physics workshop courses for two decades. Dan edits the *WebSights* column of the AAPT journal *The Physics Teacher* since 2002 and is a proud member of the AMTA and American Association of Physics Teachers.

Slides:

**1&2: Title and Abstract with URL <physicsed.buffalostate.edu/pubs/WND2017/>**

**3: Video Vignette excerpt of classroom physics modeling:**

Video of effective (as measured by student conceptual score gain from pre- and post-testing with the Hestenes’ *Force Concept Inventory*) introductory mechanics instruction of community college students.

* What is going on in this classroom?
* What events are promoting learning?
* Watch the video and make a few notes on noteworthy behaviors that are taking place that you believe are promoting learning.

Falconer, K.A., Joshua, M., & Desbien D. (2003) (Authors & Producers; SUNY-BSC Production; MacIsaac analysis). *RTOP Video 4: Modeling via Intensive Student Discourse.* [QuickTime Web Streamed Video 10:15]. Buffalo, NY: Authors. Retrieved December, 2017 from <http://PhysicsEd.BuffaloState.Edu/pubs/WND2017/>.

Many similar and longer classroom modeling physics discourse videos are available from <https://vimeo.com/channels/modelingphysics> and <http://univ-modelinginstruction.com/>

**4: Roughly three main sections:**

* + student small group data gathering and discussion activity
  + student whole class   
    “circle white-boarding” discourse,
  + teacher briefly warrants some knowledge and sets up next activity

5: **Student data gathering**

* students enter class and go right to work (cued from last day “model how a ball bounces”)
* students obviously comfortable with working on own
* student tools and representations “hammers” are whiteboarding, SONAR and x-v-a vs. t plots
* teacher is seeding different groups with different questions – pushing in different directions, different parts of the puzzle
* unique tool to some groups – energy pie charts

6: **Circle Whiteboarding**

* student trained in taking turns and sharing the air
* explicit use of model building and selection is evident
* new tool (energy pie chart analysis) gets significant billing
* jargon control of vocabulary (noun Nazis) emphasizes student thought

7: **Teacher warranting knowledge**

* advanced language control -- vocabulary manipulation (grudgingly allows new jargon, focuses on few but critical issues)
* warrants certain classroom learning (or forces agreement)
* sharply limited “closure” setting up next

8: **Overall**

* + - student meaning centered class
    - highly motivated and on-task group (sense of control and empowerment)
    - student discourse intensive (Vygotsky)
    - lots of active instructor manipulation of classroom activity, environment and student thought (loaded balls)
    - strong scientific thought – observational, phenomenological, theory building, much discourse, other videos would show prediction and testing yet to come
    - quite Machiavellian actually

**9: Modeling Synopsis**

* Curricula best developed in High School / first year college and university physics. Many US High School teachers teach multiple subjects and similar curricula have been / are in development for other US HS subjects (Chemistry, Physical Science, Biology etc).
* While originally a National Science Foundation project, now an extensive teacher-driven community supported via AMTA (American Modeling Teachers’ Association), listservs, online videos and curricula, dedicated conferences, websites, blogs, Physics Education Research literature base including dissertations and teacher’s guides / manuals, and national summer workshops (1,146 participants in 61 workshops in all year 2017). AMTA claims 11,000 modeling teachers (approximately 10%) in US (Jackson, 2017).

**10: Modeling Cycle:**Students are led to develop test and deploy expert pedagogue -chosen approximate and appropriate models from selected physical experiments called “paradigm labs.” E.g. in first semester mechanics main eight physical models are:

1. Scientific Thinking (Experiments, data modeling via graphs and algebra, and linearizing data to develop fitting equations)
2. v\_constant (constant velocity) motion
3. a\_constant (constant acceleration) motion
4. Sigma\_F = 0 (balanced forces) motion
5. Sigma\_F = ma (unbalanced forces) motion
6. 2D motion (particularly projectiles)
7. F\_central (uniform circular and curved) motion
8. E\_cons (energy conservation)
9. P\_cons (momentum conservation)

After developing the model, students “deploy” the model via more standard worksheets, quizzes, challenges, projects, lab practica and tests.

**11: Evaluation**

Modeling Instruction is designated as an *Exemplary K-12 Science Program* and a *Promising K-12 Educational Technology Program* by two expert panels of the *U.S. Department of Education*. It received the *2014 Excellence in Physics Education Award* from the *American Physical Society* (the US equivalent of German *DPG*).

Hake, R.R. (1998, January).  Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1) 64-74.

Hestenes, D., Wells, M. & Swackhamer, G.  (1992, March).  Force concept inventory.  *The Physics Teacher*, 30(3) 141-153.

**12: Final words**

* Modeling pedagogy is learner centered, cooperative inquiry (language mediated social constructivism after Vygotsky) making extensive use of whiteboards to ground and represent discourse (facilitates student thought & communication, teacher monitoring & evaluation).
* Intensive student discourse in strongly expert teacher and curriculum established learning spaces or envelopes. Discourse is managed by instructors via many intervention strategies described in Megowan and Desbien dissertations E.g.: Circle white boarding, seeding, zooming, delay / denial of closure, multiple representational tools, etc.
* Modeling makes great use of PER literature, “touchstone activities,” expert developed learning progressions, activities, representational tools, and curriculum from other sources. Much intellectual adoption and repurposing.

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**13: References:**

Wells, M., Hestenes, D. & Swackhamer, G. (1995, July). A modeling method for high school physics instruction. *American Journal of Physics,* 63(7), 606-619.

Hake, R.R. (1998, January).  Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66(1) 64-74.

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<https://modelinginstruction.org/>

<http://modeling.asu.edu/History-ModelingInstruction.htm>

<http://modeling.asu.edu/>

<http://modeling.asu.edu/listserv.html>

<https://lists.asu.edu/cgi-bin/wa?A0=MODELING&t=&X=B5D17D5B342C806585>

ModInstructionSynopsis2017nation.doc; private communication w/J. Jackson 14.10.2017 available from the author.

Video: A Modeling Approach To Physics Instruction (WNET. 12 minutes, includes Seth Guinals-Kuperman & Fernand Brunschwig): <https://www.youtube.com/watch?v=CIgGuwjCSQU>

Heheman, G (2017). 2017 Annual Report Modeling Workshops. Private communication available from the author.

Slide art:





