References

1. Ambrose, B. S. (2004). "Investigating student understanding in intermediate mechanics: Identifying the need for a tutorial approach to instruction," American Journal of Physics **72**, 453-459.

2. Ambrose, B. S., and Michael C. Wittmann. (2014). *Intermediate Mechanics Tutorials* http://faculty.gvsu.edu/ambroseb/research/IMT.html

3. Barniol, Pablo, and Genaro Zavala, "Test of understanding of vectors: A reliable multiple-choice vector concept test," Phys. Rev. ST Phys. Educ. Res. **10**, 010121-1–010121-14 (2014).

4. Bing, Thomas J., and E. F. Redish. (2009). "Analyzing problem solving using math in physics: Epistemological framing via warrants," Physical Review Special Topics – Physics Education Research **5**, 020108.

5. Christensen, Warren, David E. Meltzer, and C.A. Ogilvie. (2009). "Student ideas regarding entropy and the second law of thermodynamics in an introductory physics course," American Journal of Physics **77**, 907-917.

6. Christensen, Warren M., Ngoc-Loan Nguyen, and David E. Meltzer. (2004). "Student difficulties with graphical representation of vector products: crossing and dotting beyond t's and i's," poster presentation at the 2004 Physics Education Research Conference, Sacramento, California, August 4-5, 2004. Direct download: http://www.physicseducation.net/talks/PERC_Vector_poster.ppt

7. Christensen, Warren M., and John R. Thompson. (2010). "Investigating student understanding of physics concepts and the underlying calculus concepts in thermodynamics," *Proceedings of the 13th Annual Conference on Research in Undergraduate Mathematics Education* (Mathematical Association of America, Oberlin, OH).

8. Christensen, Warren M., and John R. Thompson. (2012). "Investigating graphical representations of slope and derivative without a physics context," Physical Review Special Topics - Physics Education Research **8** 023101.

9. Coletta, V. P., & Phillips, J. A. (2005). "Interpreting FCI scores: Normalized gain, preinstruction scores, and scientific reasoning ability," American Journal of Physics **73**, 1172.

10. Coletta, V. P., J. A. Phillips, and J. J. Steinert. (2007). "Interpreting force concept inventory scores: Normalized gain and SAT scores," Physical Review Special Topics-Physics Education Research **3**, 010106.

11. Ding, Lin, Ruth Chabay, Bruce Sherwood, and Robert Beichner. (2006). "Evaluating an electricity and magnetism assessment tool: Brief electricity and magnetism assessment," Physical Review Special Topics - Physics Education Research **2**, 010105.

12. Dray, Tevian, and Corinne A. Manogue. (1999). "The Vector Calculus Gap: Mathematics ≠ Physics," PRIMUS [Problems, Resources, and Issues in Mathematics Undergraduate Studies] **9**, 21-28.

13. Dray, T., and C. A. Manogue. (2003). "Using differentials to bridge the vector calculus gap," College Mathematics Journal, **34**(4), 283-290.

14. Dray, T., and C. A. Manogue. (2004). "Bridging the gap between mathematics and physics," APS Forum on Education Newsletter Spring, 13-14.

15. Epstein, Jerome, "The Calculus Concept Inventory," in *Proceedings of the National STEM Assessment Conference [Science, Technology, Engineering, and Mathematics], October 19-21, 2006, Washington, D.C.*, edited by Donald Deeds and Bruce Callen (Drury University, Springfield, MO, 2007), pp. 60-67; Epstein, Jerome, "Development and Validation of the Calculus Concept Inventory," in *Proceedings of the Ninth International Conference on Mathematics Education in a Global Community*, 7-12 September 2007, edited by Pugalee, Rogerson, & Schinck; online at http://math.unipa.it/~grim/21_project/21_charlotte_EpsteinPaperEdit.pdf.

16. Epstein, Jerome. (2013). "The Calculus Concept Inventory: Measurement of the effect of teaching methodology in mathematics," *Notices of the AMS* **60**, 1018-1026.

17. Flores, Sergio, Stephen E. Kanim, and Christian H. Kautz, "Student use of vectors in introductory mechanics," Am. J. Phys. **72**, 460-468 (2004).

18. Galle, Gillian, and Dawn Meredith. (2014). "The trouble with trig," The Physics Teacher **52**, 112-114.

19. Gire, Elizabeth, and Edward Price. (2013). "Arrows as anchors: Conceptual blending and student use of electric field vector arrows," *2012 Physics Education Research Conference*, edited by P. V. Engelhardt et al. AIP Conf. Proc. **1513**, pp. 150–153.

20. Gupta, Ayush, and Andrew Elby. (2011). "Beyond epistemological deficits: Dynamic explanations of engineering students' difficulties with mathematical sense-making," International Journal of Science Education **33**, 2463-2488.

21. Knight, Randall D., "Vector knowledge of beginning physics students," Phys. Teach. **33**, 74-77 (1995).

22. Larson, Christine, and Michelle Zandieh. (2013). "Three interpretations of the matrix equation A**x**=**b**," For the Learning of Mathematics **33**(2), 11-17.

23. Manogue, C. A., K. Browne, T. Dray, and B. Edwards. (2006). "Why is Ampère's law so hard? A look at middle-division physics," American Journal of Physics **74**, 344.

24. McDermott, L. C., P. S. Shaffer, and the Physics Education Group. (2002-2003). *Tutorials in Introductory Physics; Homework for Tutorials in Introductory Physics; Instructor's Guide for Tutorials in Introductory Physics,* (Prentice-Hall, Upper Saddle River, NJ).

25. Meltzer, David E. (2002). "The relationship between mathematics preparation and conceptual learning gains in physics: A possible 'hidden variable' in diagnostic pretest scores," American Journal of Physics **70**, 1259-1268.

26. Meltzer, David E. (2004). "Investigation of students' reasoning regarding heat, work, and the first law of thermodynamics in an introductory calculus-based general physics course," Am. J. Phys. **72**, 1432-1446 (2004).

27. Meltzer, David E. (2007). "Analysis of shifts in students' reasoning regarding electric field and potential concepts," in *2006 Physics Education Research Conference [Syracuse, New York (USA), 26-27 July 2006]*, edited by Laura McCullough, Leon Hsu, and Paula Heron [American Institute of Physics Conference Proceedings **883**, 177-180.

28. Meltzer, David E., and Ronald K. Thornton. (2012). "Resource Letter ALIP-1: Active-learning instruction in physics," American Journal of Physics **80**, 478-496; *direct download*: http://www.physicseducation.net/docs/Meltzer_and_Thornton_2012.pdf.

29. Meltzer, David E., and Ronald K. Thornton. (2013a). *Research-based Active-Learning Instruction in Physics*, at the 2013 Winter Meeting of the American Association of Physics Teachers, New Orleans, Louisiana, January 7, 2013 [Session AD]. Available at: http://www.physicseducation.net/talks/contributed.php.

30. Meltzer, David E., and Ronald K. Thornton. (2013b). *Research-based Active-Learning Instruction in Physics*, at the 2013 American Physical Society April Meeting, Denver, Colorado, April 13, 2013 [Bulletin of the American Physical Society II, **58 (4)**, Session B15 (2013)]. Available at: http://www.physicseducation.net/talks/contributed.php.

31. Meltzer, David E. (2013a). *The "Fully Interactive" Physics Lecture: Active-Learning Instruction in a Large-Enrollment Setting*, invited talk at the Canadian Association of Physicists Congress 2013, Université de Montréal, Montréal, Québec, Canada, May 30, 2013 [Session R-TEACH-1]. Available at: http://www.physicseducation.net/talks/index.php.

32. Meltzer, David E. (2013b). *The Development of Physics Education Research and Research-Based Physics Instruction in the United States*, plenary talk at the 2013 conference on Foundations and Frontiers of Physics Education Research, Bar Harbor, Maine, June 17, 2013. Available at: http://www.physicseducation.net/talks/index.php.

33. Nguyen, Ngoc-Loan P., and David E. Meltzer. (2003). "Initial understanding of vector concepts among students in introductory physics courses," American Journal of Physics **71**, 630-638; *direct download:* http://www.physicseducation.net/docs/AJP-71-630-638.pdf.

34. Pepper, R. E., S. V. Chasteen, S. J. Pollock, and K. K. Perkins. (2012). "Observations on student difficulties with mathematics in upper-division electricity and magnetism," Physical Review Special Topics-Physics Education Research **8**, 010111.

35. Pollock, E. B., J. R. Thompson, and D. B. Mountcastle. (2007). "Student understanding of the physics and mathematics of process variables in P-V diagrams," AIP Conf. Proc. **951**, 168.

36. Pollock, Steven J., and S. V. Chasteen. (2009). "Longer term impacts of transformed courses on student conceptual understanding of E&M," in *2009 Physics Education Research Conference [Ann Arbor, MI, 29-30 July 2009]*, edited by M. Sabella, C. Henderson, and C. Singh, AIP Conference Proceedings Volume **1179** (AIP, Melville, NY, 2009), pp. 237-240.

37. Sherin, B. L. (2001). "How students understand physics equations," Cognition and instruction **19**, 479-541.

38. Steinberg, Richard N., Michael C. Wittmann, and E. F. Redish. (1997). "Mathematical tutorials in introductory physics," AIP Conference Proceedings **399**, 1075; doi: 10.1063/1.53110

39. Thermo PER. (2014); Project materials available at: http://thermoper.wikispaces.com/, and the most recent project description is at http://www.physicseducation.net/current/Description_0817282.pdf.

40. Thompson, John R., Brandon R. Bucy, and Donald B. Mountcastle. (2006). "Assessing student understanding of partial derivatives in thermodynamics," in *2005 Physics Education Research Conference*, AIP Proceedings **818**, 77-80.

41. Thompson, John R., Corinne A. Manogue, David J. Roundy, and Donald B. Mountcastle. (2012). "Representations of partial derivatives in thermodynamics," in *2011 Physics Education Research Conference*, AIP Proceedings **1413**, 85-88.

42. Torigoe, Eugene, and Gary Gladding. (2007a). "Same to us, different to them: Numeric computation versus symbolic representation," in *2006 Physics Education Research Conference*, edited by L. McCullough et al. AIP Conf. Proc. **883**, pp. 153–156.

43. Torigoe, Eugene, and Gary Gladding. (2007b). "Symbols: Weapons of math destruction," in *2007 Physics Education Research Conference*, edited by L. Hsu et al., AIP Conf. Proc. **951**, pp. 200–203.

44. Torigoe, Eugene T., and Gary E. Gladding. (2011). "Connecting symbolic difficulties with failure in physics," American Journal of Physics **79**, 133-140.

45. University of Colorado (CU): E&M. (2014). **Electrostatics:** http://www.colorado.edu/physics/EducationIssues/Electrostatics/materials.html and **Electrodynamics:** http://www.colorado.edu/physics/EducationIssues/Electrodynamics/tutorials.html

46. University of Colorado (CU): Mechanics. (2014). http://www.colorado.edu/physics/EducationIssues/ClassicalMechanics/materials.html

47. Wagner, Joseph F., Corinne A. Manogue, and John R.Thompson. (2012). "Representation issues: Using mathematics in upper-division physics," in *2011 Physics Education Research Conference*, AIP Proceedings **1413**, 89-92.

48. Wawro, Megan, Chris Rasmussen, Michelle Zandieh, George Franklin Sweeney, and Christine Larson. (2012). "An Inquiry-Oriented Approach to Span and Linear Independence: The Case of the Magic Carpet Ride Sequence," PRIMUS **22**, 577-599.

49. Wittmann, M. C., R. N. Steinberg, E. F. Redish, and University of Maryland Physics Education Research Group. (2004). *Activity-Based Tutorials* (Vols. 1 and 2). (Wiley, New York.)