## Using Math in Physics: Warrants and Epistemological Frames

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## **Related Papers**

An Epistemic Framing Analysis of Upper-Level Physics Students' Use of Mathematics, T. J. Bing, PhD Dissertation, Department of Physics, University of Maryland (2008). [http://www.physics.umd.edu/perg/dissertations/Bing/]

Analyzing Problem Solving Using Math in Physics: Epistemic Framing via Warrants, T. J. Bing and E. F. Redish, submitted to Phys. Rev. – Special Topics in Physics Education Research (2009). [preprint http://arXiv.org/abs/0908.0028]

<u>Using warrants as a window to epistemic framing</u>, T. J. Bing and E. F. Redish, Proceedings of the Physics Education Research Conference, Edmonton, AB, July 2008, to be published. [preprint <a href="http://arXiv.org/abs/0808.1887">http://arXiv.org/abs/0808.1887</a>]

Symbolic manipulators affect mathematical mindsets, T.J. Bing and E. F. Redish, Am. J. Phys. **76**, 418-424 (2008). [preprint http://arXiv.org/abs/0712.1187]

<u>The Cognitive Blending of Mathematics and Physics Knowledge</u>, T.J. Bing and E. F. Redish, in Proceedings of the Physics Education Research Conference, Syracuse, NY, August 2006, AIP Conf. Proc. **883**, 26-29 (2007). [http://www.physics.umd.edu/perg/papers/redish/BingRedishPERC2006.pdf]

Elements of a Cognitive Model of Physics Problem Solving: Epistemic Games, J. Tuminaro and E. F. Redish, Phys. Rev. STPER, **3**, 020101 (2007). [http://www.physics.umd.edu/perg/papers/redish/T&REGames.pdf]

<u>Looking Beyond Content: Skill development for engineers</u>, E. F. Redish and K. A. Smith, Journal of Engineering Education **97**, 295-307 (July 2008). [preprint <a href="http://arXiv.org/abs/0802.2950">http://arXiv.org/abs/0802.2950</a>]

<u>Problem Solving and the Use of Math in Physics Courses</u>, E. F. Redish, to be published in Proceedings of the Conference, World View on Physics Education in 2005: Focusing on Change, Delhi, August 21-26, 2005. [preprint <a href="http://arXiv.org/abs/physics/0608268">http://arXiv.org/abs/physics/0608268</a>]

A Theoretical Framework for Physics Education Research: Modeling student thinking, Edward F. Redish, in Proceedings of the International School of Physics, "Enrico Fermi" Course CLVI, E. F. Redish and M. Vicentini (eds.) (IOS Press, Amsterdam, 2004). [preprint http://arXiv.org/abs/physics/0411149]

## **Further Reading in the PER Literature**

- D. Hammer and A. Elby, "On the Form of a Personal Epistemology," in *Personal Epistemology: The Psychology of Beliefs about Knowledge and Knowing*, edited by B.K. Hofer and P.R. Pintrich, (Erlbaum, 2002), pp. 169-190.
- A.A. diSessa and B.L. Sherin, "What changes in conceptual change?" *International Journal of Science Education*, **20**(10), 1155-1191, (1998).
- D. Hammer, "Student resources for learning introductory physics," *Am. J. Phys.*, *PER Suppl.*, **68**:7, S52-S59 (2000).
- D. Hammer, A. Elby, R. E. Scherr, & E. F. Redish, "Resources, framing, and transfer," in *Transfer of Learning: Research and Perspectives*, J. Mestre, ed. (Information Age Publishing, 2004).
- L. Lising and A. Elby, "The impact of epistemology on learning: A case study from introductory physics," *Am. J. Phys.* **73**(4), 372-382 (2005).
- S. A. Rosenberg, D. Hammer & J. Phelan, "Multiple epistemological coherences in an eighth-grade discussion of the rock cycle," *Journal of the Learning Sciences*, **15**(2), 261-292 (2006).
- K.E. Black and M.C. Wittmann, "Epistemic Games in Integration: Modeling Resource Choice," *Proceedings of the Physics Education Research Conference, Greensboro, NC, August 2007, AIP Conf. Proc.*, **951**, pp. 53-56 (2008)
- R. E. Scherr & D. Hammer, "Student behavior and epistemological framing: Examples from collaborative active-learning activities in physics," *Cognition and Instruction*, to be published (April 2009)

## **Further Reading in Other Literatures**

- D. Tannen, What's in a frame? Surface evidence for underlying expectations, in *Framing in Discourse*, edited by D. Tannen (Oxford University Press, New York, 1993) p. 14.
- D. Tannen and C. Wallat, Interactive frames and knowledge schemas in interaction: Examples from a medical examination/interview, in *Framing in Discourse*, edited by D. Tannen (Oxford University Press, New York, 1993) p. 57.
- I. Goffman, *Frame Analysis: An essay on the organization of experience* (Northeastern U. Press, 1997).