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Zachary A. Pardos - CV
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EDUCATION

Worcester Polytechnic Institute, Worcester, MA
DOE/NSF Fellow Ph.D., Computer Science   July, 2006–May, 2012

My background is in applying probabilistic graphical models to virtual learning environments in order to infer cognitively diagnostic information about the students and the contexts in which they learn. This research may be applied to increase the efficiency of assessment and assistance in a tutor and, with further development and study, enable scientific insight into how students learn and how best to enable that learning. My publications are in the areas of learning analytics and machine learning with 25 collaborators on topics such as predictive modeling, personalization, ensemble methods and affect.

Graduate GPA: 3.86 - Graduation: May 12th, 2012
Ph.D Committee: Neil Heffernan (advisor) , Ryan Baker, Gabor Sarkozy, Ken Koedinger (CMU)

Masters of Science, Computer Science   May, 2009
*Bachelor of Science with **High Distinction**, Computer Science*   May, 2006

Denver Technical College, Denver, CO
*Associates of Science with **Honors**, Information Systems Programming*   Feb, 2002

WORK EXPERIENCE

MIT – Education Research Specialist (Computer Science AI Lab)   present
- Projects in MOOC course quality inference and resource efficacy inference
- Mentor of masters and undergrad students working on education analysis projects
- Scaling model fitting procedures to accommodate personalization and real-time application
- Supervisors: Una-May O'Reilly (ALFA Lab, CSAIL), Rob Miller (HCI, EECS)

MIT – Postdoctoral Associate (Department of Physics - Visiting)   Sept. 2012-January 2013
- Adapting Bayesian Cognitive modeling paradigms to edX MOOC data
- Supervisor: David Pritchard (RELATE Lab, Research Lab of Electronics)

WPI – Ph.D. Research Fellow (with Neil Heffernan)   2006-2012
- Developed methods in learning analytics to improve the efficiency of assessment and instruction
- Co-advised 11 masters and Ph.D. students producing 16 publications between 2011 and 2012
- Seven years of experience working with a web-math tutoring system called ASSISTments

BAE Systems – Internship (Washington, D.C)   Summer 2008
- Worked with the chief research scientist to develop and test a trusted routing protocol aimed at adding accountability to wide area networks (DARPA seedling project)
- Gained experience with network data analysis, computer network defense and cyber warfare.

SERVICE/LEADERSHIP EXPERIENCE (in Learning Analytics)

- Member of the 2013 Learning Analytics Summer Institute (July 1st-5th, Stanford)
- Program Committee member of the 5th & 6th International Conference on Educational Data Mining (EDM'12-13) and the 16th International Artificial Intelligence in Education conference (AIED2013)
- Invited Strata 2013 conference panelist with Jace Kohlmeier (Khan Academy), Marie Bienkowski (SRI) and Prasad Ram (Gooru Learning) to speak about the state of student modeling in K-16.
- Co-chair with Emily Schneider (Stanford) of the workshop on Massive Open Online Courses at the 16th International Conference on Artificial Intelligence in Education (http://www.moocshop.org)
- European Commission expert reviewer – Technology enhanced education, 2013
- National Science Foundation grant panelist – Information & Intelligent Systems Division, 2012
- Member of the 2012 working group on building the field of learning analytics (Roy Pea, director)
- Reviewer: Journal of Educational Data Mining (Board of Reviewers), ACM Transactions on Interactive Intelligent Systems Journal, ACM Transactions on Computer Human Interaction; Artificial Intelligence in Education, Educational Data Mining, Intelligent Tutoring Systems, and

User Modeling, Adaptation and Personalization conferences.

- Co-chair with Michel Desmarais (PolyMTL) of the workshop on Factorization Models at the User Modeling and Adaptive Personalization conference (UMAP2012)
- Nominee for the International Educational Data Mining Society Board of Directors (1 of 12)
- Co-chair with John Stamper (CMU) of the workshop on Knowledge Discovery in Educational Data at the ACM's Special Interest Group on Knowledge Discovery and Data mining conference (SIGKDD2011)
- Mentor at Carnegie Mellon's PSLC summer camp on educational data mining, 2011, 2012, 2013
- Program Committee member for the Handbook of Educational Data Mining (2009)

AWARDS and HONORS

International / National

- National Science Foundation Fellowship – Graduate students in K-12 Education, 2008-2012
- ACM's KDD Cup, international data mining competition on educational data: 2nd place prize – 2010
    - Featured the largest dataset in KDD Cup competition history (30 million student actions)
    - WPI news story on the event and solution: http://www.wpi.edu/news/20101/2010zach.html
- Sigma Xi Scientific Research Society Associate Member, inducted April 2010
- International Conference on Educational Data Mining (EDM) 2009: Best Student Paper award
- Department of Education Fellowship - Graduate Assistance in Areas of National Need, 2007-2009
- Upsilon Pi Epsilon (UPE) Computing and Information Systems Honors Society, inducted April 2008

Worcester Polytechnic Institute

- Graduate Research Achievement Day[1]: 1st place (co-author w/Trivedi – master's student) – 2012
    - For work on out of sample spectral clustering extensions and regularity lemma clustering
- Graduate Research Achievement Day: 1st place in Science category (Physics/Math/CS) - 2011
    - For work on developing individualized models of student learning with Bayesian networks
- Computer Science Department Research Award: 1st place (co-author w/Trivedi) – 2011
    - For work on bagged k-means clustering for prediction tasks
- Graduate Research Achievement Day: 2nd place in Science category (Physics/Math/CS) - 2010
    - For work on Expectation Maximization initialization sensitivity in Bayesian student models
- Computer Science Department's nominee for the WPI Graduate Fellowship Award - 2010

MACHINE LEARNING EXPERIENCE

- Bayesian Networks (7 years experience)
- Big data analysis / ROCKS computing clusters
- MATLAB Distributed and Parallel Computing
- Clustering (k-means, Spectral, Regularity)
- Simulation / Data synthesis
- Logistic regression (on millions of features)
- Random Forests, [Ensembles, SVM,NN,DBN]
- Feature engineering and feature generation

TEACHING EXPERIENCE

- Guest lectured the graduate course (PSY505) on Advanced Methods and Analysis for the Learning and Social Sciences, Spring 2012
- Guest lectured the graduate course (CS534) on Artificial Intelligence, Spring 2012
- Guest lectured and created projects for the undergraduate course (CS4341) on Artificial Intelligence, Spring 2011
- Co-taught the first graduate course (CS525) on Educational Data Mining at WPI with Neil Heffernan. Taught 60% of lectures and planned all projects and readings, Fall 2010
- Taught 6th-11th grade math once a week and helped teachers integrate tutoring technology into their classroom curriculum for four school years, Fall 2008 to Spring 2012

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[1] Graduate Research Achievement Day (GRAD) is an annual campus event where graduate students from every department display and present a poster summarizing their research. The posters and presentations are judged by faculty and other members of the community. Judges award honors to the top three posters in each of the four divisions: Science, Engineering, Business/Social Science, and Life Sciences/Bioengineering.

Most Recent

Pardos, Z.A., Bergner, Y., Seaton, D., Pritchard, D.E., In press (2013) Adapting Bayesian Knowledge Tracing to a Massive Open Online College Course in edX. In Proceedings of *the 6th International Conference on Educational Data Mining (EDM 2013).* Memphis, TN, U.S.A ***Best paper nominated***

Falakmasir, M. H., Pardos, Z. A., Gordon, G. J., Brusilovsky, P., In press (2013). A Spectral Learning Approach to Knowledge Tracing. In Proceedings of *the 6th International Conference on Educational Data Mining (EDM 2013).* Memphis, TN, U.S.A. ***Best student paper nominated***

Veeramachaneni, K., Pardos, Z. A., O'Reilly, U., Accepted (2013) EDSciDB: Developing standards and backend support for MOOC Data Science. To appear in *Proceedings of the First Annual Workshop on Massive Open Online Courses (moocshop) at the 2013 International Conference on Artificial Intelligence in Education (AIED2013)*. Memphis, TN, U.S.A

Pardos, Z. A., Yudelson, M., Accepted (2013) Towards Moment of Learning Accuracy. To appear in *Proceedings of the Simulated Learners Workshop at the 2013 International Conference on Artificial Intelligence in Education (AIED2013)*. Memphis, TN, U.S.A

Pardos, Z.A., Baker, R.S.J.d., San Pedro, M.O.C.Z., Gowda, S.M., Gowda, S.M. (2013) Affective states and state tests: Investigating how affect throughout the school year predicts end of year learning outcomes. In *Proceedings of* the 3rd *International Conference on Learning Analytics and Knowledge (LAK2013)*. Leuven, Belgium.

Clustering

Pardos, Z.A., Trivedi, S., Heffernan, N. T., Sarkozy, G. (2012) Clustered Knowledge Tracing. In *Proceedings of the 11th International Conference on Intelligent Tutoring Systems*. Crete, Greece. Pages 405-410

Trivedi, S. Pardos, Z., Sarkozy, G. & Heffernan, N.T. (2012) Co-Clustering by Bipartite Spectral Graph Partitioning for Out-Of-Tutor Prediction. In *Proceedings of the 5th International Conference on Educational Data Mining.* Crete, Greece. Pages. 33-40.

Trivedi, S., Pardos, Z. & Heffernan, N. (2011) Clustering Students to Generate an Ensemble to Improve Standard Test Score Predictions In Biswas et al (Eds) *Proceedings of the 15th bi-annual Artificial Intelligence in Education Conference*. Springer. LNAI 6738, Pages. 328–336.

Trivedi, S., Pardos, Z., Sarkozy, G. & Heffernan, N. (2011) Spectral Clustering in Educational Data Mining. In Pechenizkiy, M., Calders, T., Conati, C., Ventura, S., Romero , C., and Stamper, J. (Eds.) *Proceedings of the 4th International Conference on Educational Data Mining*. Pages 129-138.

Trivedi S, Pardos Z. A., Heffernan N. T., (under review) The Utility of Clustering in Prediction Tasks. *IEEE Transactions on Systems, Man and Cybernetics, Part B*. ***WPI research award***

Trivedi, S. Pardos, Z., Sarkozy, G. & Heffernan, N. T. (under review) Out of Sample Extensions to Spectral Clustering. *Springer Journal on Statistics and Computing*. ***WPI research award***

Knowledge Representation

Karlovcec, M., Cardova-Sanchez, M., Pardos, Z.A. (2012) Knowledge Component Suggestion for Untagged Content in an Intelligent Tutoring System. In *Proceedings of the 11th International Conference on Intelligent Tutoring Systems*. Crete, Greece. Pages 195-200

Pardos, Z. A., Heffernan, N. T., Anderson, B., Heffernan, C. (2010) Using Fine-Grained Skill Models to Fit Student Performance with Bayesian Networks. In C. Romero, S. Ventura, S. R. Viola, M. Pechenizkiy and R. S. J. Baker (Eds.) *Handbook of Educational Data Mining*. CRC Press, Pages. 417-426.

Pardos, Z. A., Beck, J., Ruiz, C. & Heffernan, N. T. (2008). The Composition Effect: Conjunctive or Compensatory? An Analysis of Multi-Skill Math Questions in ITS. In Baker, R.S.J.d., Barnes, T., Beck, J.E. (Eds.) *Proceedings of the first International Conference on Educational Data Mining*. Montreal, Canada. Pages 147-156.

Pardos, Z. A., Heffernan, N. T., Ruiz, C. & Beck, J. (2008) Effective Skill Assessment Using Expectation Maximization in a Multi Network Temporal Bayesian Network. In *Proceedings of The Young Researchers Track at the 9th International Conference on Intelligent Tutoring Systems*. Montreal, Canada.

Pardos, Z., Feng, M. & Heffernan, N. T. & Heffernan-Lindquist, C. (2007). Analyzing fine-grained skill models using bayesian and mixed effect methods. In Luckin & Koedinger (Eds.) *Proceedings of*

the 13th Conference on Artificial Intelligence in Education. IOS Press. Pages 626-628

Pardos, Z. A., Heffernan, N. T., Anderson, B. & Heffernan, C. (2007). The effect of model granularity on student performance prediction using Bayesian networks. *Proceedings of the 11th International Conference on User Modeling*. Springer Berlin. Pages 435-439.

Razzaq, L., Heffernan, N.T., Feng, M., Pardos, Z.A. (2007) Developing Fine-Grained Transfer Models in the ASSISTment System. *Journal of Technology, Instruction, Cognition, and Learning*, Vol. 5. Number 3. Old City Publishing, Philadelphia, PA. 2007. Pages 289-304.

Student modeling individualization and prediction

Falakmasir, M. H., Pardos, Z. A., Gordon, G. J., Brusilovsky, P., In press (2013). A Spectral Learning Approach to Knowledge Tracing. In Proceedings of *the 6th International Conference on Educational Data Mining (EDM 2013).* Memphis, TN, U.S.A. **Best student paper nominated*

Pardos, Z.A., Baker, R.S.J.d., San Pedro, M.O.C.Z., Gowda, S.M., Gowda, S.M. (2013) Affective states and state tests: Investigating how affect throughout the school year predicts end of year learning outcomes. In *Proceedings of* the *3rd International Conference on Learning Analytics and Knowledge*. Leuven, Belgium.

Falakmasir, M.H., Pardos, Z.A., Gordon, G.J., Brusilovsky, P. (under review). A Spectral Learning Approach to Knowledge Tracing. Under review at *the 6th International Conference on Educational Data Mining*. Memphis, TN.

Pardos, Z.A., Gowda, S. M., Baker, R. S.J.D., Heffernan, N. T. (2012) The Sum is Greater than the Parts: Ensembling Models of Student Knowledge in Educational Software. In *ACM's Knowledge Discovery and Datamining (KDD) Explorations*, 13(2)

Pardos, Z.A., Heffernan, N. T. (In Press) Using HMMs and bagged decision trees to leverage rich features of user and skill from an intelligent tutoring system dataset. *Journal of Machine Learning Research W & CP. *Invited article *WPI research award *KDD Cup solution article*

Pardos, Z.A., Wang, Q. Y., Trivedi, S. (2012) The real world significance of performance prediction. In *Proceedings of the 5th International Conference on Educational Data Mining.* Crete, Greece. Pages 192-195

Yumeng, Q., Pardos, Z.A., Heffernan, N.T. (2012) Towards data driven user model improvement. In *Proceedings of the 25th annual Florida Artificial Intelligence Research Society Conference*. 2012

Qiu, Y., Qi, Y., Lu, H., Pardos, Z. & Heffernan, N.T. (2011) Does Time Matter? Modeling the Effect of Time with Bayesian Knowledge Tracing In Pechenizkiy, M., Calders, T., Conati, C., Ventura, S., Romero , C., and Stamper, J. (Eds.) *Proceedings of the 4th International Conference on Educational Data Mining*. Pages 139-148.

Baker, R., Pardos, Z., Gowda, S., Nooraei, B., & Heffernan, N. (2011) Ensembling Predictions of Student Knowledge within Intelligent Tutoring Systems. In Konstant et al (Eds.) *Proceedings of the 20th International Conference on User Modeling, Adaptation and Personalization* (UMAP 2011). Pages 13-24.

Nooraei, B., Pardos, Z.A., Heffernan, N.T., Baker, R.S.J.d (2011) Less Is More: Improving the Speed and Prediction Power of Knowledge Tracing by Using Less Data. *Proceedings of the 4th International Conference on Educational Data Mining*. Pages 101-110.

Xiong, X., Pardos, Z. A., Heffernan, N.T. (2011) An Analysis of Response Time Data for Improving Student Performance Prediction. In *Proceedings of the workshop on Educational Data at the 17th Conference on Knowledge Discovery and Data Mining (ACM SIGKDD).* San Diego, CA.

Wang, Q., Kherer, Pardos, Z. A., Heffernan, N.T. (2011) Response Tabling – A simple and practical compliment to Knowledge Tracing. In *Proceedings of the workshop on Educational Data at the 17th Conference on Knowledge Discovery and Data Mining (ACM SIGKDD).* San Diego, CA.

Feng, M., Heffernan, N., Pardos, Z. & Heffernan, C. Establishing the value of dynamic assessment in an online tutoring system In Pechenizkiy, M., Calders, T., Conati, C., Ventura, S., Romero , C., and Stamper, J. (Eds.) *Proceedings of the 4th International Conference on Educational Data Mining*. Pages 295-300.

Pardos, Z. A., Heffernan, N. T. (2010) Modeling Individualization in a Bayesian Networks Implementation of Knowledge Tracing. In P. De Bra, A. Kobsa, D. Chin (Eds.) *Proceedings of the 18th International Conference on User Modeling, Adaptation and Personalization*. Big Island of Hawaii. Pages. 255-266. **Best student paper nominated*

Pardos, Z. A., Heffernan, N. T. (2010) Navigating the Parameter Space of Bayesian Knowledge Tracing Models: Visualizations of the convergence of the EM algorithm. In Baker, R.S.J.d.,

Merceron, A., Pavlik, P.I. Jr. (Eds.) *Proceedings of the 3rd International Conference on Educational Data Mining*. Pittsburg, PA. Pages. 161-170. ***WPI research award***

Tutor evaluation (modeling content for its assessment and learning value)

Pardos, Z.A., Bergner, Y., Seaton, D., Pritchard, D.E. In Press (2013) Adapting Bayesian Knowledge Tracing to a Massive Open Online College Course in edX. Under review at *the 6th International Conference on Educational Data Mining*. Memphis, TN. ***Best paper nominated***

Rau, M.A., Aleven, V., Rummel, N., Pardos, Z.A. (under review) How should intelligent tutoring systems sequence multiple graphical representations of fractions? A multi-method approach. Under review at *the International Journal of Artificial Intelligence in Education*.

Pardos, Z.A., Heffernan, N.T. (2012) Tutor Modeling vs. Student Modeling. In *Proceedings of the 25th annual Florida Artificial Intelligence Research Society conference*. 2012 ***Invited article***

Gowda, S., Pardos, Z.A., Baker, S.J.D.R. (2012) Content learning analysis using the moment-by-moment learning detector. In *Proceedings of the 11th International Conference on Intelligent Tutoring Systems*. Crete, Greece. Pages 434-443

Rau, M., Pardos, Z.A. (2012) Interleaved Practice with Multiple Representations: Analyses with Knowledge Tracing Based Techniques. In *Proceedings of the 5th annual International Conference on Educational Data Mining.* Crete, Greece. Pages 168-171

Pardos, Z. & Heffernan, N. (2011) KT-IDEM: Introducing Item Difficulty to the Knowledge Tracing Model. In Konstant et al (Eds.) *Proceedings of the 20th International Conference on User Modeling, Adaptation and Personalization* (UMAP 2011). Pages. 243-254.

Pardos, Z.A., Dailey, M. & Heffernan, N. (2011) Learning what works in ITS from non-traditional randomized controlled trial data. *The International Journal of Artificial Intelligence in Education*, 21(1-2):45-63.

Pardos, Z. A., Dailey, M. N., Heffernan, N. T. (2010) Learning what works in ITS from non-traditional randomized controlled trial data. In V. Aleven, J. Kay, J. Mostow (Eds.) *Proceedings of the 10th International Conference on Intelligent Tutoring Systems*. Pittsburg, PA. Vol. 2. Pages 41-50. ***Best student paper nominated***

Pardos, Z. A., Heffernan, N. T. (2009) Determining the Significance of Item Order in Randomized Problem Sets. In Barnes, Desmarais, Romero & Ventura (Eds.) In *Proceedings of the 2nd International Conference on Educational Data Mining*. Cordoba, Spain. Pages 111-120. ***Best student paper winner***

Pardos, Z. A., Heffernan, N. T. (2009) Detecting the Learning Value of Items In a Randomized Problem Set. In V. Dimitrova, R. Mizoguchi, B. du Boulay, A. Graesser (Eds.) *Proceedings of the 14th International Conference on Artificial Intelligence in Education*. Brighton, UK. Pages 499-507.

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