

# Curriculum Vitae

## Pat Langley

### Personal Information

#### *ASU Address:*

Computer Science and Engineering  
Arizona State University, Tempe, AZ 85287  
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#### *ISLE Address:*

Institute for the Study of Learning and Expertise  
2164 Staunton Court, Palo Alto, CA 94306  
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### Education

Carnegie Mellon University, M.S., 1976, Ph.D., 1980, Cognitive Psychology

Texas Christian University, B.A., 1975, Mathematics and Psychology

### Employment/Administrative History

Professor of Computing and Informatics / Psychology, Arizona State University, Tempe, Arizona  
(8/06–present)

Director and President, Institute for the Study of Learning and Expertise, Palo Alto, CA (9/88–present)

Consulting Professor of Symbolic Systems, Stanford University, and Head, Computational Learning  
Laboratory, Center for the Study of Language and Information (1/1/97–9/09)

Head, Adaptive Systems Group, DaimlerChrysler Research & Technology Center (9/1/96–10/31/00)

Senior Research Associate, Robotics Laboratory, Stanford University (1/94–9/96)

Senior Scientist, Learning Systems Department, Siemens Corporate Research (12/92–12/93)

Senior Scientist, AI Research Branch, NASA Ames Research Center (9/89–9/92)

Associate Professor, Department of Computer Science, University of California, Irvine, CA (7/84–6/91)

Research Scientist, The Robotics Institute, Carnegie Mellon University, Pittsburgh, PA (9/81–6/84)

Research Associate, Department of Psychology, Carnegie Mellon University, Pittsburgh, PA (9/79–8/81)

### Grants, Contracts, and Gifts

A UNIFIED COMPUTATIONAL THEORY OF LANGUAGE AND COGNITION, Office of Naval Research  
(MURI program) [~\$4,400,000] 6/1/09 – 5/31/12 (co-PI's N. Cassimatis, J. Hobbs, S. Nirenburg)

SOFTWARE INTEGRATION FOR COMPUTATIONAL COGNITIVE MODELS IN VIRTUAL ENVIRONMENTS,  
AFOSR [\$228,702] 7/1/09 – 7/14/11 (Subcontract through SET Corporation, PI A. Pope)

AN INTRODUCTORY COURSE IN SCIENCE INFORMATICS, Microsoft Research [\$50,000] 5/1/08 – 4/30/10

SYMPOSIUM ON COMPUTATIONAL APPROACHES TO CREATIVITY IN SCIENCE, NSF [\$18,000] 2/1/08  
– 1/31/09 (Co-PI W. Bridewell)

COMPUTATIONAL APPROACHES TO CREATIVITY THROUGH GOAL-DIRECTED CROSS-DOMAIN ANAL-  
OGY, NSF [\$199,828] 8/16/07 – 2/28/10 (Co-PI S. Kambhampati)

LEARNING HIERARCHICAL TASK MODELS FROM BEHAVIORAL TRACES, Defense Advanced Research  
Projects Agency [\$1,045,367] 4/1/06 – 3/31/09 (Subcontract through BBN, PI M. Burstein)

TRANSFER LEARNING IN INTEGRATED COGNITIVE SYSTEMS, Defense Advanced Research Projects  
Agency [\$12,242,291] 10/1/05 – 4/30/10 (Co-PIs P. Domingos, L. Holder, and others)

LEARNING HIERARCHICAL RELATIONAL SKILLS FROM KNOWLEDGE AND EXPERIENCE, Defense Ad-  
vanced Research Projects Agency [\$1,571,070] 11/1/03 – 10/31/06

COMPUTATIONAL INDUCTION OF SCIENTIFIC PROCESS MODELS, NSF [\$2,650,000] 9/15/03 – 9/14/09  
(Co-PIs K. Arrigo and B. Widrow)

NEW RESEARCH DIRECTIONS IN COGNITIVE ARCHITECTURES, NSF [\$99,271] 9/1/03 – 6/30/05

- COMBINING SHALLOW SEMANTICS AND DOMAIN KNOWLEDGE, Scottish Enterprise through Edinburgh University and Stanford University [\$351,000] 4/1/2004 – 3/31/2007 (Co-PI C. Manning)
- SYMPOSIUM ON REASONING AND LEARNING IN COGNITIVE SYSTEMS, ONR [\$5,100], NSF [\$4,500] 3/1/04 – 2/28/05 (Co-PI S. Rogers)
- SYMPOSIUM ON MACHINE LEARNING FOR ANOMALY DETECTION, NSF [\$5,600] 5/1/04 – 11/1/04 (Co-PI S. Bay)
- SYMPOSIUM ON ADVANCES IN COGNITIVE ARCHITECTURES, DARPA [\$10,000], NSF [\$7,510] 3/1/03 – 2/28/04 (Co-PI D. Shapiro)
- INTERACTIVE COMPUTATIONAL ASSISTANT FOR VIDEO SEGMENTATION AND CLASSIFICATION, Media X, Stanford University [\$22,129] 4/1/2003 – 8/31/2003] (Co-PIs C. Manning and M. Gervasio)
- COMPUTATIONAL DISCOVERY OF COMMUNICABLE KNOWLEDGE, Nippon Telegraph and Telephone Company [\$623,657] 10/16/00 – 10/15/05
- COMPUTATIONAL TECHNIQUES FOR RECONSTRUCTION AND DISCOVERY OF METABOLIC, SIGNAL TRANSDUCTION, AND EVOLUTIONARY PATHWAYS, NASA Ames Research Center [\$348,500] 7/1/01 – 6/30/04 (Co-PIs A. Pohorille and J. Shrager)
- FILTERING INFORMATION IN COMPLEX TEMPORAL DOMAINS, NASA Ames Research Center [\$776,000] 3/1/01 – 7/31/04
- COMPUTATIONAL DISCOVERY OF KNOWLEDGE IN EARTH SCIENCE, NASA Ames Research Center [\$175,000] 7/1/99 – 3/31/01
- ADAPTIVE USER INTERFACES FOR CRISIS RESPONSE TASKS, Office of Naval Research [\$580,000] 8/1/99 – 7/31/01
- ADAPTIVE CRISIS RESPONSE: INTELLIGENT ASSISTANTS FOR JOINT-FORCE CRISIS RESPONSE, Office of Naval Research [\$3,000,000] 9/1/96 – 8/31/99 (co-PI M. Fehling)
- LEARNING OBJECT MODELS FROM VISUAL OBSERVATION AND BACKGROUND KNOWLEDGE, Office of Naval Research and ARPA [\$615,832] 6/1/94 – 3/31/00 (co-PI T. Binford)
- MACHINE LEARNING FOR ROBOTIC LOCALIZATION AND NAVIGATION, Office of Naval Research [\$281,658] 3/1/94 – 2/28/97
- COMPUTATIONAL MODELS OF HUMAN LEARNING WITH INSTRUCTIONAL RELEVANCE, Air Force Office of Scientific Research [\$308,167] 1/1/94 – 12/31/97 (co-PI N. Nilsson)
- WORKSHOP ON FIELDIED APPLICATIONS OF MACHINE LEARNING, Office of Naval Research [\$4,800] 6/1/93 – 12/31/93 (Co-PI Y. Kodratoff)
- SYMPOSIUM ON LEARNING METHODS FOR PLANNING AND SCHEDULING, DARPA [\$5,200], ONR [\$5,100], AAAI [\$5,000] 1/1/91 – 12/31/91 (Co-PI S. Minton)
- SYMPOSIUM ON COMPUTATIONAL APPROACHES TO CONCEPT FORMATION, NSF [\$5,000], ONR [\$5,000], AAAI [\$5,000] 1/1/90 – 12/31/90 (Co-PI D. Fisher)
- SYMPOSIUM ON COMPUTATIONAL MODELS OF SCIENTIFIC DISCOVERY, National Science Foundation [\$7,300], Office of Naval Research [\$5,000], American Association for Artificial Intelligence [\$5,000] 1/1/89 – 12/31/89 (Co-PI J. Shrager)
- FOURTH INTERNATIONAL WORKSHOP ON MACHINE LEARNING, NSF [\$7,001], ONR [\$5,000], DARPA [\$5,000], AAAI [\$10,000] 1/1/87 – 12/31/87
- A LABORATORY FOR SOFTWARE RESEARCH, National Science Foundation Coordinated Experimental Research Grant, 7/1/86 – 6/30/91 [\$3,131,000] (Co-PI's P. Freeman, N. Leveson, R. Razouk, R. Selby, T. Standish, R. Taylor)
- LEARNING IN A REACTIVE ENVIRONMENT, DARPA, 7/1/85 – 8/30/86 [\$250,127], Army Research Institute [\$1,381,907] 9/1/85 – 8/31/90 (Co-PI's D. Kibler and R. Granger)
- MACHINE LEARNING RESEARCH, Hughes Aircraft, [\$60,000] 7/1/85 – 6/30/87 (Co-PI D. Kibler)
- FOCUSED RESEARCH PROGRAM IN COMPUTATION AND LEARNING, University of California, Irvine [\$100,000] 7/1/85 – 6/30/88 (Co-PI K. Wexler)
- THE EFFECT OF MULTIPLE KNOWLEDGE SOURCES ON LEARNING AND TEACHING, Office of Naval Research [\$324,926] 7/1/85 – 6/30/88 (Co-PI D. Kibler)

RESEARCH IN MACHINE LEARNING, ONR [\$375,000] 1/1/84 – 12/31/86 (Co-PI J. G. Carbonell)  
 MODELING THE STRATEGIES OF MATHEMATICS STUDENTS, ONR [\$203,425] 12/1/82 – 11/30/84  
 DATA-DRIVEN DISCOVERY OF EMPIRICAL LAWS, Office of Naval Research [\$205,674] 2/15/82 – 12/31/83  
 (Co-PI H. A. Simon)

## Research Interests

Unified cognitive architectures	Computational scientific discovery
Computational models of human cognition	Science informatics and e-science
Problem solving and reasoning	Computational biology and ecology
Synthetic characters for virtual environments	Human-robot interaction
Machine learning and induction	Adaptive interfaces and personalization

## Professional Memberships

American Association for Artificial Intelligence (Fellow), Cognitive Science Society (Fellow)  
 Association for Computing Machinery (SIG for Knowledge Discovery and Data Mining)

## Courses Taught *(at UCI, Stanford University, and Arizona State University)*

Introduction to Artificial Intelligence – Winter, 1985; Fall, 1986, 1987  
 AI Projects/Programming Techniques – Winter, 1986; Spring, 1986, 1988  
 Introduction to Machine Learning – Spring, 1985, 1986, 1987, 1991; Winter, 1995; Spring, 1996  
 Production System Models of Learning and Development – Winter, 1987  
 Projects in Artificial Intelligence – Spring, 1986  
 Readings/Projects in Artificial Intelligence – Fall, 1985, 1986; Spring, 1986  
 Experimental Methodologies for Machine Learning – Winter, 1988  
 Computational Models of Learning and Development – Spring, 1995  
 Adaptive Interfaces and User Modeling – Spring, 1999, 2000  
 Causal Models in Biomedical Informatics – Winter, 2003  
 Reasoning and Learning in Cognitive Systems – Winter, 2004, 2005, 2006  
 Computational Approaches to Scientific Reasoning and Discovery – Spring, 2004, 2005  
 Cognitive Systems and Intelligent Agents – Spring, 2007, 2008, 2009, Fall, 2009  
 Introduction to Science Informatics – Spring, 2009

## Postdoctoral Mentorships

Brian Yamauchi (1995–1996)	Marcus Maloof (1996–1998)
Simon Handley (1997–1998)	Cindi Thompson (1998–2000)
Will Bridewell (2004–2009)	Ljupčo Todorovski (2004–2005)
Stuart Borrett (2005–2007)	Tolga Könik (2005–2010)
David Stracuzzi (2005–2007)	Stephen Racunas (2005–2007)

## Doctoral Committees *(completed dissertations in italics)*

<i>Douglas Fisher</i> , Member (1984–1987)	<i>Jeff Schlimmer</i> , Member (1985–1987)
<i>Randy Jones</i> , Chair (1985–1989)	<i>Bernd Nordhausen</i> , Chair (1985–1989)
<i>Wayne Iba</i> , Chair (1986–1991)	<i>John Gennari</i> , Chair (1986–1990)
<i>James Wogulis</i> , Member (1986–1990)	Patrick Young, Chair (1986–1988)
Kevin Thompson, Chair (1986–1992)	<i>Donald Rose</i> , Chair (1984–1989)
<i>Klaus Gross</i> , Member (1989–1991)	John Allen, Chair (1988–1992)
<i>Ron Kohavi</i> , Member (1996)	<i>George John</i> , Member (1994–1997)
<i>Ofer Maitan</i> , Member (1997)	<i>Daniel Shapiro</i> , Co-Chair (1997–2000)
Dongkyu Choi, Chair (2003–2010)	Nima Asgharbeygi, Co-Chair (2004–2010)
Oren Shiran, Co-Chair (2003–2005)	Negin Nejati, Co-Chair (2003–2010)
Nan Li, Chair (2006–2009)	Chunki Park, Co-Chair (2005–2010)

## Professional Service

Reviewer, National Science Foundation, 1986–1988, 1991, 1994, 1998, 2002, 2004, 2005  
 Reviewer, International Joint Conference on Artificial Intelligence, 1983, 1985, 1987, 1989, 1995, 2001  
 Program committee, International Joint Conference on Artificial Intelligence, 1989  
 Program committee, AAAI Conference on Artificial Intelligence, 1987–1988, 1991, 1996–1997, 2005  
 Program co-chair, AAAI Integrated Intelligence track, 2007, 2008, 2010  
 Program chair, International Workshop/Conference on Machine Learning, 1987, 2000  
 Program committee, International Conference on Machine Learning, 1988/89, 1991/93/97, 2000/02/03/04/05  
 Reviewer, Annual Meeting of the Cognitive Science Society, 1985, 1993, 1994, 2004, 2010  
 Program committee, International Conference on the Foundations of Digital Games, 2009  
 Reviewer, *Cognitive Science*, 1986, 1987, 1994, 2001–2008  
 Editorial board, *Cognitive Science*, 2003–2005  
 Reviewer, *Artificial Intelligence*, 1986, 1988, 1993, 1994  
 Associate, *Behavioral and Brain Sciences*, 1987–1991  
 Executive Editor, *Machine Learning*, 1985–1988  
 Editor, *Machine Learning*, 1989–1990, 1996–1998  
 Editorial board, *Machine Learning*, 1985–2010  
 Editorial board, *Journal of Artificial Intelligence Research*, 1993–1996  
 Reviewer, *Journal of Artificial Intelligence Research*, 1993–1996, 2003, 2005  
 Editorial board, *Knowledge Discovery and Data Mining*, 1996–2009  
 Editor, Morgan Kaufmann Series in Machine Learning, 1990–1999  
 Co-organizer, Symposium on Computational Models of Scientific Discovery, 1989  
 Co-organizer, Symposium on Computational Approaches to Concept Formation, 1990  
 Co-organizer, Symposium on Learning Methods for Planning and Scheduling, 1991  
 Co-organizer, Workshop on Fielded Applications of Machine Learning, 1993  
 Organizing committee, AAAI Spring Symposium on Integrated Intelligent Architectures, 1991  
 Program committee, International Conference on AI Planning Systems, 1992, 1994, 1996, 2004  
 Co-presenter – AAAI/IJCAI Tutorial on Machine Learning – 1985, 1986, 1988, 1992  
 Organizer and co-presenter – CSLI Tutorial on Applications of Machine Learning – 1994–1996, 1998  
 Organizing committee, AAAI Workshop on Computational Models of Human Learning, 1996  
 Co-editor, special issue of *Machine Learning* on learning with probabilistic representations, 1997  
 Program co-chair, Nineteenth Annual Conference of the Cognitive Science Society, 1997  
 Co-organizer, Symposium on Applications of Reinforcement Learning, 1998  
 Organizer, Symposium on Computational Discovery of Communicable Knowledge, 2001  
 Co-organizer, Symposium on Advances in Cognitive Architectures, 2003  
 Co-organizer, Symposium on Reasoning and Learning in Cognitive Systems, 2004  
 Co-organizer, Symposium on Machine Learning for Anomaly Detection, 2004  
 Co-organizer, Symposium on Computational Approaches to Creativity in Science, 2008  
 Co-organizer, Symposium on Systems Biology of Aging, 2008

## University Service

Industrial Affiliates Committee (Chair), ICS Department, UCI, 1984–1985  
 Faculty Chair, ICS Department, UCI, 1984–1985  
 Computing Resources Committee, ICS Department, UCI, 1985–1986  
 Executive Committee, ICS Department, UCI, 1985–1986  
 Organizer, Seminar on Computational Learning and Adaptation, Stanford University, 1994–2006  
 Consulting Professor, Symbolic Systems Program, Stanford University – 1996–2005  
 Symbolic Systems Program Masters Committee, Stanford University, 1997–1998  
 CSLI Distinguished Lecture Series Committee, Stanford University, 1999–2001  
 CSLI Advisory Committee, Stanford University, 2003–2007  
 Executive Committee, Department of Computer Science, Arizona State University, 2008–2009

## Books

- [1] Langley, P. (Ed.) (2000). *Proceedings of the Seventeenth International Conference on Machine Learning*. Stanford, CA: Morgan Kaufmann.
- [2] Shafto, M. G., & Langley, P. (Eds.) (1997). *Proceedings of the Nineteenth Annual Conference of the Cognitive Science Society*. Mahwah, NJ: Lawrence Erlbaum.
- [3] Langley, P. (1995). *Elements of Machine Learning*. San Francisco: Morgan Kaufmann.
- [4] Fisher, D. H., Pazzani, M. J., & Langley, P. (Eds.) (1991). *Concept Formation: Knowledge and Experience in Unsupervised Learning*. San Francisco: Morgan Kaufmann.
- [5] Shrager, J., & Langley, P. (Eds.) (1990). *Computational Models of Scientific Discovery and Theory Formation*. San Francisco: Morgan Kaufmann.
- [6] Langley, P. (Ed.) (1987). *Proceedings of the Fourth International Workshop on Machine Learning*. San Francisco: Morgan Kaufmann.
- [7] Langley, P., Simon, H. A., Bradshaw, G. L., & Żytkow, J. M. (1987). *Scientific Discovery: Computational Explorations of the Creative Processes*. Cambridge, MA: MIT Press.
- [8] Klahr, D., Langley, P., & Neches, R. (Eds.) (1987). *Production System Models of Learning and Development*. Cambridge, MA: MIT Press.

## Refereed Journal Articles

- [1] Bridewell, W. & Langley, P. (2010). Two kinds of knowledge in scientific discovery. *Topics in Cognitive Science*, 2, 36–52.
- [2] Könik, T., O’Rorke, P., Shapiro, D., Choi, D., Nejati, N., & Langley, P. (2009). Skill transfer through goal-driven representation mapping. *Cognitive Systems Research*, 10, 270–285.
- [3] Langley, P., Choi, D., & Rogers, S. (2009). Acquisition of hierarchical reactive skills in a unified cognitive architecture. *Cognitive Systems Research*, 10, 316–332.
- [4] Langley, P., Laird, J. E., & Rogers, S. (2009). Cognitive architectures: Research issues and challenges. *Cognitive Systems Research*, 10, 141–160.
- [5] Cassimatis, N. L., Bello, P., & Langley, P. (2008). Ability, breadth and parsimony in computational models of higher-order cognition. *Cognitive Science*, 32, 1304–1322.
- [6] Bridewell, W., Langley, P., Todorovski, L., & Džeroski, S. (2008). Inductive process modeling. *Machine Learning*, 71, 1–32.
- [7] Bridewell, W., Billman, D., Sánchez, J. N., & Langley, P. (2006). An interactive environment for the modeling and discovery of scientific knowledge. *International Journal of Human-Computer Studies*, 64, 1099–1114.
- [8] Langley, P., Shiran, O., Shrager, J., Todorovski, L., & Pohorille, A. (2006). Constructing explanatory process models from biological data and knowledge. *Artificial Intelligence in Medicine*, 37, 191–201.
- [9] Langley, P., & Choi, D. (2006). Learning recursive control programs from problem solving. *Journal of Machine Learning Research*, 7, 493–518.
- [10] Asgharbeygi, N., Bay, S., Langley, P., & Arrigo, K. (2006). Inductive revision of quantitative process models. *Ecological Modelling*, 194, 70–79.
- [11] Jones, R. M., & Langley, P. (2005). A constrained architecture for learning and problem solving. *Computational Intelligence*, 21, 480–502.
- [12] Schroedl, S., Wagstaff, K., Rogers, S., Langley, P., & Wilson, C. (2004). Mining GPS traces for map refinement. *Knowledge Discovery and Data Mining*, 9, 59–87.
- [13] Thompson, C. A., Göker, M. H., & Langley, P. (2004). A personalized system for conversational recommendations. *Journal of Artificial Intelligence Research*, 21, 393–428.
- [14] Ichise, R., Shapiro, D., & Langley, P. (2004). Structured program induction from behavioral traces. *IEICE Transactions on Information and Systems*, J87-D-1, 730–740 (in Japanese).

- [15] Todorovski, L., Džeroski, S., Langley, P., & Potter, C. (2003). Using equation discovery to revise an Earth ecosystem model of carbon net production. *Ecological Modelling*, *170*, 141–154.
- [16] Bay, S. D., Shragar, J., Pohorille, A., & Langley, P. (2003). Revising regulatory networks: From expression data to linear causal models. *Journal of Biomedical Informatics*, *35*, 289–297.
- [17] Maloof, M. A., Langley, P., Binford, T. O., Nevatia, R., & Sage, S. (2003). Improved rooftop detection in aerial images with machine learning. *Machine Learning*, *53*, 157–191.
- [18] Langley, P. (2000). The computational support of scientific discovery. *International Journal of Human-Computer Studies*, *53*, 393–410.
- [19] Kocabas, S., & Langley, P. (2000). Computer generation of process explanations in nuclear astrophysics. *International Journal of Human-Computer Studies*, *53*, 377–392.
- [20] Blum, A. L., & Langley, P. (1997). Selection of relevant features and examples in machine learning. *Artificial Intelligence*, *97*, 245–271.
- [21] Yamauchi, B., & Langley, P. (1997). Place recognition in dynamic environments. *Journal of Robotic Systems*, *14*, 107–120.
- [22] Langley, P., Pflieger, K., & Sahami, M. (1997). Lazy acquisition of place knowledge. *Artificial Intelligence Review*, *11*, 315–342.
- [23] Langley, P., & Simon, H. A. (1995). Applications of machine learning and rule induction. *Communications of the ACM*, *38*, November, 55–64.
- [24] Nordhausen, B., & Langley, P. (1993). An integrated framework for empirical discovery. *Machine Learning*, *12*, 17–47.
- [25] Langley, P., & Żytkow, J. M. (1989). Data-driven approaches to empirical discovery. *Artificial Intelligence*, *40*, 283–312.
- [26] Gennari, J. H., Langley, P., & Fisher, D. H. (1989). Models of incremental concept formation. *Artificial Intelligence*, *40*, 11–61.
- [27] Iba, W., & Langley, P. (1987). A computational theory of motor learning. *Computational Intelligence*, *3*, 338–350.
- [28] Żytkow, J. M., Langley, P., & Simon, H. A. (1987). Computer system of discovery STAHL. *Studia Filozoficzne or Zagadnienia Naukoznawstwa*, *23*, 518–536.
- [29] Rose, D., & Langley, P. (1986). Chemical discovery as belief revision. *Machine Learning*, *1*, 423–451.
- [30] Langley, P. (1985). Learning to search: From weak methods to domain-specific heuristics. *Cognitive Science*, *9*, 217–260.
- [31] Langley, P., Larson, P., Silas, S., & Wertz, S. (1983). A proof of CNQNP from CPQ by the rule of detachment in Jeffrey’s system 5.6. *International Logic Review*, *14*, 37–40.
- [32] Bradshaw, G. L., Langley, P., & Simon, H. A. (1983). Studying scientific discovery by computer simulation. *Science*, *222*, 971–975.
- [33] Langley, P. (1983). Representational issues in learning systems. *IEEE Computer*, *16*, 47–51.
- [34] Langley, P. (1983). Learning search strategies through discrimination. *International Journal of Man-Machine Studies*, *18*, 513–541.
- [35] Langley, P. (1982). Language acquisition through error recovery. *Cognition and Brain Theory*, *5*, 211–255.
- [36] Simon, H. A., Langley, P., & Bradshaw, G. L. (1981). Scientific discovery as problem solving. *Synthese*, *47*, 1–27.
- [37] Langley, P. (1981). Data-driven discovery of physical laws. *Cognitive Science*, *5*, 31–54.
- [38] Langley, P., Neches, R., Neves, D., & Anzai, Y. (1980). A domain-independent framework for learning procedures. *International Journal of Policy Analysis and Information Systems*, *4*, 163–197.
- [39] Langley, P. (1979). A production system model for the induction of mathematical functions. *Behavioral Science*, *24*, 121–139.

## Refereed Conference Papers

- [1] Park, C., Bridewell, W., & Langley, P. (in press). Integrated systems for inducing spatio-temporal process models. *Proceedings of the Twenty-Fourth AAAI Conference on Artificial Intelligence*. Atlanta: AAAI Press.
- [2] Li, N., Stracuzzi, D. J., Langley, P., & Nejati, N. (2009). Learning hierarchical skills from problem solutions using means-ends analysis. *Proceedings of the Thirty-First Annual Meeting of the Cognitive Science Society*. Amsterdam.
- [3] Stracuzzi, D. J., Li, N., Cleveland, G., & Langley, P. (2009). Representing and reasoning over time in a cognitive architecture. *Proceedings of the Thirty-First Annual Meeting of the Cognitive Science Society*. Amsterdam.
- [4] Li, N., Stracuzzi, D., & Langley, P. (2008). Learning conceptual predicates for teleoreactive logic programs. *Proceedings of the Eighteenth International Conference on Inductive Logic Programming: Late-Breaking Papers*. Prague: Springer.
- [5] Li, N., Choi, D., & Langley, P. (2007). Adding goal priorities to teleoreactive logic programs. *Proceedings of the First International Symposium on Skill Science*. Tokyo, Japan.
- [6] Könik, T., Choi, D., Shapiro, D., Park, C., Nejati, N., Langley, P., & Stracuzzi, D. (2007). Structural transfer of cognitive skills. *Proceedings of the Eighth International Conference on Cognitive Modeling*. Ann Arbor, MI.
- [7] Choi, D., Könik, T., Nejati, N., Park, C., & Langley, P. (2007). A believable agent for first-person shooter games. *Proceedings of the Third Annual Artificial Intelligence and Interactive Digital Entertainment Conference* (pp. 71–73). Stanford, CA: AAAI Press.
- [8] Bridewell, W., Langley, P., Racunas, S., & Borrett, S. R. (2006). Learning process models with missing data. *Proceedings of the Seventeenth European Conference on Machine Learning* (pp. 557–565). Berlin: Springer.
- [9] Langley, P., & Choi, D. (2006). A unified cognitive architecture for physical agents. *Proceedings of the Twenty-First National Conference on Artificial Intelligence*. Boston: AAAI Press.
- [10] Nejati, N., Langley, P., & Könik, T. (2006). Learning hierarchical task networks by observation. *Proceedings of the Twenty-Third International Conference on Machine Learning* (pp. 665–672). Pittsburgh, PA.
- [11] Asgharbeygi, N., Langley, P., & Stracuzzi, D. (2006). Relational temporal difference learning. *Proceedings of the Twenty-Third International Conference on Machine Learning* (pp. 49–56). Pittsburgh, PA.
- [12] Choi, D., & Langley, P. (2005). Learning teleoreactive logic programs from problem solving. *Proceedings of the Fifteenth International Conference on Inductive Logic Programming* (pp. 51–68). Bonn, Germany: Springer.
- [13] Bridewell, W., Bani Asadi, N., Langley, P., & Todorovski, L. (2005). Reducing overfitting in process model induction. *Proceedings of the Twenty-Second International Conference on Machine Learning* (pp. 81–88). Bonn, Germany.
- [14] Asgharbeygi, N., Nejati, N., Langley, P., & Arai, S. (2005). Guiding inference through relational reinforcement learning. *Proceedings of the Fifteenth International Conference on Inductive Logic Programming* (pp. 20–37). Bonn, Germany: Springer.
- [15] Todorovski, L., Shiran, O., Bridewell, W., & Langley, P. (2005). Inducing hierarchical process models in dynamic domains. *Proceedings of the Twentieth National Conference on Artificial Intelligence* (pp. 892–897). Pittsburgh, PA: AAAI Press.
- [16] Langley, P., & Rogers, S. (2005). An extended theory of human problem solving. *Proceedings of the Twenty-seventh Annual Meeting of the Cognitive Science Society*. Stresa, Italy.
- [17] Langley, P., & Rogers, S. (2004). Cumulative learning of hierarchical skills. *Proceedings of the Third International Conference on Development and Learning*. San Diego, CA.

- [18] Langley, P., & Cummings, K. (2004). Hierarchical skills and cognitive architectures. *Proceedings of the Twenty-Sixth Annual Conference of the Cognitive Science Society* (pp. 779–784). Chicago, IL.
- [19] Choi, D., Kaufman, M., Langley, P., Nejati, N., & Shapiro, D. (2004). An architecture for persistent reactive behavior. *Proceedings of the Third International Joint Conference on Autonomous Agents and Multi Agent Systems* (pp. 988–995). New York: ACM Press.
- [20] Langley, P., Shrager, J., Asgharbeygi, N., Bay, S., & Pohorille, A. (2004). Inducing explanatory process models from biological time series. *Proceedings of the Ninth Workshop on Intelligent Data Analysis and Data Mining* (pp. 85–90). Stanford, CA.
- [21] Sanchez, J. N., & Langley, P. (2003). An interactive environment for scientific model construction. *Proceedings of the Second International Conference on Knowledge Capture* (pp. 138–145). Sanibel Island, FL: ACM Press.
- [22] George, D., Saito, K., Langley, P., Bay, S., & Arrigo, K. (2003). Discovering ecosystem models from time-series data. *Proceedings of the Sixth International Conference on Discovery Science* (pp. 141–152). Saporro, Japan: Springer.
- [23] Langley, P., George, D., Bay, S., & Saito, K. (2003). Robust induction of process models from time-series data. *Proceedings of the Twentieth International Conference on Machine Learning* (pp. 432–439). Washington, D.C.: AAAI Press.
- [24] Yoo, J., Gervasio, M., & Langley, P. (2003). An adaptive stock tracker for personalized trading recommendations. *Proceedings of the International Conference on Intelligent User Interfaces* (pp. 197–203). Miami, Florida.
- [25] Chrisman, L., Langley, P., Bay, S., & A. Pohorille (2003). Incorporating biological knowledge into evaluation of causal regulatory hypotheses. *Proceedings of the Pacific Symposium on Biocomputing* (pp. 128–139). Lihue, Hawaii.
- [26] Saito, K., Bay, S., & Langley, P. (2002). Revising qualitative models of gene regulation. *Proceedings of the Fifth International Conference on Discovery Science* (pp. 59–70). Lubeck, Germany: Springer.
- [27] Ichise, R., Shapiro, D. G., & Langley, P. (2002). Learning hierarchical skills from observation. *Proceedings of the Fifth International Conference on Discovery Science* (pp. 247–258). Lubeck, Germany: Springer.
- [28] Bay, S. D., Shapiro, D. G., & Langley, P. (2002). Revising engineering models: Combining computational discovery with knowledge. *Proceedings of the Thirteenth European Conference on Machine Learning* (pp. 10–22). Helsinki, Finland.
- [29] Langley, P., Sanchez, J., Todorovski, L., & Džeroski, S. (2002). Inducing process models from continuous data. *Proceedings of the Nineteenth International Conference on Machine Learning* (pp. 347–354). Sydney: Morgan Kaufmann.
- [30] Shapiro, D., & Langley, P. (2002). Separating skills from preference: Using learning to program by reward. *Proceedings of the Nineteenth International Conference on Machine Learning* (pp. 570–577). Sydney: Morgan Kaufmann.
- [31] Shrager, J., Langley, P., & Pohorille, A. (2002). Guiding revision of regulatory models with expression data. *Proceedings of the Pacific Symposium on Biocomputing* (pp. 486–497). Lihue, Hawaii.
- [32] Saito, K., Langley, P., Grenager, T., Potter, C., Torregrosa, A., & Klooster, S. A. (2001). Computational revision of quantitative scientific models. *Proceedings of the Fourth International Conference on Discovery Science* (pp. 336–349). Washington, D.C.: Springer.
- [33] Kocabas, S., & Langley, P. (2001). An integrated framework for extended discovery in particle physics. *Proceedings of the Fourth International Conference on Discovery Science* (pp. 182–195). Washington, D.C.: Springer.
- [34] Kalton, A., Langley, P., Wagstaff, K., & Yoo, J. (2001). Generalized clustering, supervised learning, and data assignment. *Proceedings of the Seventh International Conference on Knowledge Discovery and Data Mining* (pp. 299–304). San Francisco: ACM Press.

- [35] Schwabacher, M., & Langley, P. (2001). Discovering communicable scientific knowledge from spatio-temporal data. *Proceedings of the Eighteenth International Conference on Machine Learning* (pp. 489–496). Williamstown, MA: Morgan Kaufmann.
- [36] Shapiro, D., Langley, P., & Shachter, R. (2001). Using background knowledge to speed reinforcement learning in physical agents. *Proceedings of the Fifth International Conference on Autonomous Agents* (pp. 254–261). Montreal: ACM Press.
- [37] Langley, P., & Stromsten, S. (2000). Learning context-free grammars with a simplicity bias. *Proceedings of the Eleventh European Conference on Machine Learning* (pp. 220–228). Barcelona: Springer-Verlag.
- [38] Rogers, S., Langley, P., & Wilson, C. (1999). Learning to predict lane occupancy using GPS and digital maps. *Proceedings of the Fifth International Conference on Knowledge Discovery and Data Mining* (pp. 104–113). San Diego, CA: ACM Press.
- [39] Langley, P. (1999). Concrete and abstract models of category learning. *Proceedings of the Twenty-First Annual Conference of the Cognitive Science Society* (pp. 288–293). Vancouver, BC: Lawrence Erlbaum.
- [40] Gervasio, M. T., Iba, W., & Langley, P. (1999). Learning user evaluation functions for adaptive scheduling assistance. *Proceedings of the Sixteenth International Conference on Machine Learning* (pp. 152–161). Bled, Slovenia: Morgan Kaufmann.
- [41] Langley, P., & Sage, S. (1999). Tractable average-case analysis of naive Bayesian classifiers. *Proceedings of the Sixteenth International Conference on Machine Learning* (pp. 220–228). Bled, Slovenia: Morgan Kaufmann.
- [42] Rogers, S., Fiechter, C., & Langley, P. (1999). An adaptive interactive agent for route advice. *Proceedings of the Third International Conference on Autonomous Agents* (pp. 198–205). Seattle: ACM Press.
- [43] Shapiro, D., & Langley, P. (1999). Controlling physical agents through reactive logic programming. *Proceedings of the Third International Conference on Autonomous Agents* (pp. 386–387). Seattle: ACM Press.
- [44] Handley, S., Langley, P., & Rauscher, F. (1998). Learning to predict the duration of an automobile trip. *Proceedings of the Fourth International Conference on Knowledge Discovery and Data Mining*. New York: AAAI Press.
- [45] Iba, W., Gervasio, M., Langley, P., & Sage, S. (1998). Experimental studies of intelligent assistance for crisis response. *Proceedings of the Twentieth Annual Conference of the Cognitive Science Society*. Madison, WI: Lawrence Erlbaum.
- [46] Moriarty, D. E., Handley, S., & Langley, P. (1998). Learning distributed strategies for traffic control. *Proceedings of the Fifth International Conference of the Society for Adaptive Behavior*. Zurich.
- [47] Gervasio, M., Iba, W., & Langley, P. (1998). Learning to predict user operations for adaptive scheduling. *Proceedings of the Fifteenth National Conference on Artificial Intelligence* (pp. 721–726). Madison, WI: AAAI Press.
- [48] Moriarty, D., & Langley, P. (1998). Learning cooperative lane selection strategies for highways. *Proceedings of the Fifteenth National Conference on Artificial Intelligence* (pp. 684–691). Madison, WI: AAAI Press.
- [49] Kohavi, R., Langley, P., & Yun, Y. (1997). The utility of feature weighting in nearest-neighbor algorithms. *Proceedings of the Ninth European Conference on Machine Learning*. Prague: Springer-Verlag.
- [50] Langley, P. (1997). Learning to sense selectively in physical domains. *Proceedings of the First International Conference on Autonomous Agents* (pp. 217–226). Marina del Rey, CA: ACM Press.
- [51] John, G. H., & Langley, P. (1996). Static vs. dynamic sampling for data mining. *Proceedings of the Second International Conference of Knowledge Discovery and Data Mining* (pp. 367–370). Portland. AAAI Press.
- [52] Langley, P. (1996). Induction of condensed determinations. *Proceedings of the Second International Conference of Knowledge Discovery and Data Mining* (pp. 327–330). Portland: AAAI Press.

- [53] Langley, P. (1996). An abstract computational model of learning selective sensing skills. *Proceedings of the Eighteenth Annual Conference of the Cognitive Science Society* (pp. 385–390). San Diego: Lawrence Erlbaum.
- [54] Jones, R., & Langley, P. (1995). Retrieval and learning in analogical problem solving. *Proceedings of the Seventeenth Annual Conference of the Cognitive Science Society* (pp. 466–471). Pittsburgh: Lawrence Erlbaum.
- [55] John, G. H., & Langley, P. (1995). Estimating continuous distributions in Bayesian networks. *Proceedings of the Eleventh Conference on Uncertainty in Artificial Intelligence* (pp. 338–345). Montreal, Quebec: Morgan Kaufmann.
- [56] Langley, P., & Pfleger, K. (1995). Case-based acquisition of place knowledge. *Proceedings of the Twelfth International Conference on Machine Learning* (pp. 244–352). Lake Tahoe, CA: Morgan Kaufmann.
- [57] Langley, P., Drastal, G., Rao, R. B., & Greiner, R. (1994). Theory revision in fault hierarchies. *Proceedings of the Fifth International Workshop on Principles of Diagnosis* (pp. 166–173). New Paltz, NY.
- [58] Langley, P., & Sage, S. (1994). Induction of selective Bayesian classifiers. *Proceedings of the Tenth Conference on Uncertainty in Artificial Intelligence* (pp. 399–406). Seattle, WA: Morgan Kaufmann.
- [59] Langley, P., & Sage, S. (1994). Oblivious decision trees and abstract cases. *Working Notes of the AAAI94 Workshop on Case-Based Reasoning* (pp. 113–117). Seattle, WA: AAAI Press.
- [60] Langley, P., Iba, W., & Shrager, J. (1994). Reactive and automatic behavior in plan execution. *Proceedings of the Second International Conference on AI Planning Systems* (pp. 299–304). Chicago: AAAI Press.
- [61] Langley, P., & Iba, W. (1993). Average-case analysis of a nearest neighbor algorithm. *Proceedings of the Thirteenth International Joint Conference on Artificial Intelligence* (pp. 889–894). Chambéry, France.
- [62] Langley, P. (1993). Induction of recursive Bayesian classifiers. *Proceedings of the 1993 European Conference on Machine Learning* (pp. 153–164). Vienna: Springer-Verlag.
- [63] Langley, P., Iba, W., & Thompson, K. (1992). An analysis of Bayesian classifiers. *Proceedings of the Tenth National Conference on Artificial Intelligence* (pp. 223–228). San Jose, CA: AAAI Press.
- [64] Langley, P. (1992). Systematic and nonsystematic search strategies. *Proceedings of the First International Conference on AI Planning Systems* (pp. 145–152). College Park, MD: Morgan Kaufmann.
- [65] Iba, W., & Langley, P. (1992). Induction of one-level decision trees. *Proceedings of the Ninth International Conference on Machine Learning* (pp. 233–240). Aberdeen, Scotland: Morgan Kaufmann.
- [66] Langley, P., & Allen, J. A. (1991). Learning, memory, and search in planning. *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society* (pp. 364–369). Chicago: Lawrence Erlbaum.
- [67] McKusick, K. B., & Langley, P. (1991). Constraints on tree structure in concept formation. *Proceedings of the Twelfth International Joint Conference on Artificial Intelligence* (pp. 810–816). Sydney: Morgan Kaufmann.
- [68] Nordhausen, B., & Langley, P. (1990). A robust approach to numeric discovery. *Proceedings of the Seventh International Conference on Machine Learning* (pp. 411–418). Austin, TX: Morgan Kaufmann.
- [69] Allen, J. A., & Langley, P. (1990). Integrating memory and search in planning. *Proceedings of the Workshop on Innovative Approaches to Planning, Scheduling, and Control* (pp. 301–312). San Diego, CA: Morgan Kaufmann.
- [70] Wogulis, J., & Langley, P. (1989). Improving efficiency by learning intermediate concepts. *Proceedings of the Eleventh International Joint Conference on Artificial Intelligence* (pp. 657–662). Detroit, MI: Morgan Kaufmann.
- [71] Rose, D., & Langley, P. (1988). A hill-climbing approach to machine discovery. *Proceedings of the Fifth International Conference on Machine Learning* (pp. 367–373). Ann Arbor, MI: Morgan Kaufmann.
- [72] Iba, W., Wogulis, J., & Langley, P. (1988). Trading off simplicity and coverage in incremental concept learning. *Proceedings of the Fifth International Conference on Machine Learning* (pp. 73–79). Ann Arbor, MI: Morgan Kaufmann.

- [73] Nordhausen, B., & Langley, P. (1987). Towards an integrated discovery system. *Proceedings of the Tenth International Joint Conference on Artificial Intelligence* (pp. 198–200). Milan, Italy: Morgan Kaufmann.
- [74] Rose, D., & Langley, P. (1987). Belief revision and induction. *Proceedings of the Ninth Annual Conference of the Cognitive Science Society* (pp. 748–752). Seattle, WA: Lawrence Erlbaum.
- [75] Rose, D., & Langley, P. (1986). STAHLp: Belief revision in scientific discovery. *Proceedings of the Fifth National Conference on Artificial Intelligence* (pp. 528–532). Philadelphia: Morgan Kaufmann.
- [76] Fisher, D., & Langley, P. (1985). Approaches to conceptual clustering. *Proceedings of the Ninth International Joint Conference on Artificial Intelligence* (pp. 691–697). Los Angeles: Morgan Kaufmann.
- [77] Langley, P., & Ohlsson, S. (1984). Automated cognitive modeling. *Proceedings of the Fourth National Conference on Artificial Intelligence* (pp. 193–197). Austin, TX: Morgan Kaufmann.
- [78] Ohlsson, S., & Langley, P. (1984). Towards automatic discovery of simulation models. *Proceedings of the European Conference on Artificial Intelligence*. Pisa, Italy.
- [79] Żytkow, J., Langley, P., & Simon, H. A. (1984). A model of early chemical reasoning. *Proceedings of the Sixth Annual Conference of the Cognitive Science Society* (pp. 378–381). Boulder, CO: Lawrence Erlbaum.
- [80] Langley, P., Ohlsson, S., Thibadeau, R., & Walter, R. (1984). Cognitive architectures and principles of behavior. *Proceedings of the Sixth Annual Conference of the Cognitive Science Society* (pp. 244–247). Boulder, CO: Lawrence Erlbaum.
- [81] Langley, P., & Sage, S. (1984). Conceptual clustering as discrimination learning. *Proceedings of the Fifth Biennial Conference of the Canadian Society for Computational Studies of Intelligence* (pp. 95–98). London, Ontario.
- [82] Sage, S., & Langley, P. (1983). Modeling development on the balance scale task. *Proceedings of the Eighth International Joint Conference on Artificial Intelligence* (pp. 94–96). Karlsruhe, West Germany: Morgan Kaufmann.
- [83] Langley, P., Bradshaw, G. L., Żytkow, J., & Simon, H. A. (1983). Three facets of scientific discovery. *Proceedings of the Eighth International Joint Conference on Artificial Intelligence* (pp. 465–468). Karlsruhe, West Germany: Morgan Kaufmann.
- [84] Langley, P. (1983). Learning effective search heuristics. *Proceedings of the Eighth International Joint Conference on Artificial Intelligence* (pp. 419–421). Karlsruhe, West Germany: Morgan Kaufmann.
- [85] Langley, P. (1983). Student modeling as strategy learning. *Proceedings of the Fifth Annual Conference of the Cognitive Science Society*. Rochester, NY: Lawrence Erlbaum.
- [86] Langley, P. (1982). A model of early syntactic development. *Proceedings of the 20th Annual Conference of the Society for Computational Linguistics* (pp. 145–151). Toronto, Ontario.
- [87] Langley, P. (1982). Strategy acquisition governed by experimentation. *Proceedings of the European Conference on Artificial Intelligence* (pp. 171–176). Orsay, France.
- [88] Langley, P., Bradshaw, G. L., & Simon, H. A. (1982). Data-driven and expectation-driven discovery of empirical laws. *Proceedings of the Fourth Biennial Conference of the Canadian Society for Computational Studies of Intelligence* (pp. 137–143). Saskatoon, Saskatchewan.
- [89] Langley, P., Bradshaw, G. L., & Simon, H. A. (1981). BACON.5: The discovery of conservation laws. *Proceedings of the Seventh International Joint Conference on Artificial Intelligence* (pp. 121–126). Vancouver, BC: Morgan Kaufmann.
- [90] Langley, P. (1980). A production system model of first language acquisition. *Proceedings of the Eighth International Conference on Computational Linguistics* (pp. 183–189). Tokyo, Japan.
- [91] Bradshaw, G. L., Langley, P., & Simon, H. A. (1980). BACON.4: The discovery of intrinsic properties. *Proceedings of the Third Biennial Conference of the Canadian Society for Computational Studies of Intelligence* (pp. 19–25). Victoria, BC.

- [92] Langley, P. (1980). Finding common paths as a learning mechanism. *Proceedings of the Third Biennial Conference of the Canadian Society for Computational Studies of Intelligence* (pp. 12–18). Victoria, BC.
- [93] Langley, P. (1979). Rediscovering physics with BACON.3. *Proceedings of the Sixth International Joint Conference on Artificial Intelligence* (pp. 505–507). Tokyo, Japan: Morgan Kaufmann.
- [94] Langley, P. (1978). BACON.1: A general discovery system. *Proceedings of the Second Biennial Conference of the Canadian Society for Computational Studies of Intelligence* (pp. 173–180). Toronto, Ontario.
- [95] Rychener, M., Forgy, C., Langley, P., McDermott, J., Newell, A., & Ramakrishna, K. (1977). Problems in building an instructable production system. *Proceedings of the Fifth International Joint Conference on Artificial Intelligence* (pp. 337). Cambridge, MA: Morgan Kaufmann.
- [96] Langley, P. (1977). BACON: A production system that discovers empirical laws. *Proceedings of the Fifth International Joint Conference on Artificial Intelligence* (pp. 344). Cambridge, MA: Morgan Kaufmann.

### Invited Chapters and Papers

- [1] Bridewell, W., Borrett, S. R., & Langley, P. (2009). Supporting the construction of dynamic scientific models. In A. Markman (Ed.), *Tools for innovation*. New York: Oxford University Press.
- [2] Langley, P., & Bridewell, W. (2008). An interdisciplinary curriculum in science informatics. In Y. Xu (Ed.), *Transform science - Computational education for scientists (Vol. 2): What to Teach?*. Redmond, WA: Microsoft Research.
- [3] Choi, D., Morgan, M., Park, C., & Langley, P. (2007). A testbed for evaluation of architectures for physical agents. *Proceedings of the AAAI-2007 Workshop on Evaluating Architectures for Intelligence*. Vancouver, BC: AAAI Press.
- [4] Borrett, S. R., Bridewell, W., Langley, P., & Arrigo, K. (2007). A method for representing and developing process models. *Ecological Complexity*, 4, 1–12.
- [5] Langley, P. (in press). Intelligent behavior in humans and machines. In J. Moor (Ed.), *AI at 50*. Publisher to be determined.
- [6] Langley, P. (in press). Artificial intelligence and cognitive systems. In P. Cohen (Ed.), *AI: The first hundred years*. Menlo Park, CA: AAAI Press.
- [7] Dietterich, T. G., & Langley, P. (2007). Machine learning for cognitive networks: Technology assessment and research challenges. In Q. Mahmoud (Ed.), *Cognitive networks: Towards self-aware networks*. New York: John Wiley.
- [8] Saito, K., & Langley, P. (2007). Quantitative revision of scientific models. In S. Džeroski & L. Todorovski (Eds.), *Computational discovery of communicable scientific knowledge*. Berlin: Springer.
- [9] Schwabacher, M., & Langley, P. (2007). Discovering communicable scientific knowledge from spatio-temporal data. In S. Džeroski & L. Todorovski (Eds.), *Computational discovery of communicable scientific knowledge*. Berlin: Springer.
- [10] Džeroski, S., Langley, P., & Todorovski, L. (2007). Computational discovery of scientific knowledge. In S. Džeroski & L. Todorovski (Eds.), *Computational discovery of communicable scientific knowledge*. Berlin: Springer.
- [11] Langley, P. (2006). Cognitive architectures and general intelligent systems. *AI Magazine*, 27, 33–44.
- [12] Langley, P. (2005). An adaptive architecture for physical agents. *Proceedings of the 2005 IEEE/WIC/ACM International Conference on Intelligent Agent Technology* (pp. 18–25). Compiègne, France: IEEE Computer Society Press.
- [13] Lavrac, N., Motoda, H., Fawcett, T., Holte, R., Langley, P., & Adriaans, P. (2004). Lessons learned from data mining applications and collaborative problem solving. *Machine Learning*, 57, 13–34.
- [14] Langley, P. (2004). Heuristics for discovery in cognitive science: The legacy of Herbert Simon. In M. E. Augier & J. G. March (Eds.), *Models of a man: Essays in memory of Herbert A. Simon*. Cambridge, MA: MIT Press.

- [15] Langley, P., Shrager, J., & Saito, K. (2002). Computational discovery of communicable scientific knowledge. In L. Magnani, N. J. Nersessian, & C. Pizzi (Eds.), *Logical and computational aspects of model-based reasoning*. Dordrecht: Kluwer Academic.
- [16] Iba, W., & Langley, P. (2001). Unsupervised learning of probabilistic concept hierarchies. In G. Paliouras, V. Karkaletsis, & C. D. Spyropoulos (Eds.), *Machine learning and its applications*. Berlin: Springer.
- [17] Langley, P., Thompson, C., Elio, R. & Haddadi, A. (1999). An adaptive conversational interface for destination advice. *Proceedings of the Third International Workshop on Cooperative Information Agents* (pp. 347–364). Uppsala, Sweden.
- [18] Langley, P. (1999). User modeling in adaptive interfaces. *Proceedings of the Seventh International Conference on User Modeling* (pp. 357–370). Banff, Alberta: Springer.
- [19] Langley, P. (1998). The computer-aided discovery of scientific knowledge. *Proceedings of the First International Conference on Discovery Science*. Fukuoka, Japan: Springer.
- [20] Langley, P. (1997). Machine learning for adaptive user interfaces. *Proceedings of the 21st German Annual Conference on Artificial Intelligence* (pp. 53–62). Freiburg, Germany: Springer.
- [21] Langley, P. (1997). Machine learning for intelligent systems. *Proceedings of the Fourteenth National Conference on Artificial Intelligence* (pp. 763–769). Providence, RI: AAAI Press.
- [22] Maloof, M. A., Langley, P., Sage, S., & Binford, T. (1997). Learning to detect rooftops in aerial images. *Proceedings of the Image Understanding Workshop*. New Orleans: Morgan Kaufmann.
- [23] Langley, P., & Sage, S. (1997). Scaling to domains with irrelevant features. In R. Greiner (Ed.), *Computational learning theory and natural learning systems* (Vol. 4). Cambridge, MA: MIT Press.
- [24] Provan, G., Langley, P., & Binford, T. O. (1996). Probabilistic learning of three-dimensional object models. *Proceedings of the Image Understanding Workshop* (pp. 1403–1413). Palm Springs, CA: Morgan Kaufmann.
- [25] Langley, P. (1995). Order effects in incremental learning. In P. Reimann & H. Spada (Eds.), *Learning in humans and machines: Towards and interdisciplinary learning science*. Oxford: Elsevier.
- [26] Kocabas, S., & Langley, P. (1995). Integration of research tasks for modeling discoveries in particle physics. *Proceedings of the AAAI Spring Symposium on Systematic Methods of Scientific Discovery* (pp. 87–92). Stanford, CA: AAAI Press.
- [27] Langley, P., Binford, T. O., & Levitt, T. S. (1994). Learning object models from visual observation and background knowledge. *Proceedings of the Image Understanding Workshop* (pp. 765–772). Monterrey, CA: Morgan Kaufmann.
- [28] Langley, P., & Allen, J. A. (1993). A unified framework for planning and learning. In S. Minton (Ed.), *Machine learning methods for planning*. San Mateo, CA: Morgan Kaufmann.
- [29] Langley, P. (1992). Areas of application for machine learning. *Proceedings of the Fifth International Symposium on Knowledge Engineering*. Seville, Spain.
- [30] Schlimmer, J. C., & Langley, P. (1992). Machine learning. In S. Shapiro (Ed.), *Encyclopedia of artificial intelligence* (2nd ed.). New York: John Wiley & Sons.
- [31] Thompson, K., & Langley, P. (1991). Concept formation in structured domains. In D. H. Fisher, M. J. Pazzani, & P. Langley (Eds.), *Concept formation: Knowledge and experience in unsupervised learning*. San Mateo, CA: Morgan Kaufmann.
- [32] Shrager, J., & Langley, P. (1990). Computational approaches to scientific discovery. In J. Shrager & P. Langley (Eds.), *Computational models of scientific discovery and theory formation*. San Mateo, CA: Morgan Kaufmann.
- [33] Fisher, D. H., & Langley, P. (1990). The structure and formation of natural categories. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in Research and Theory* (Vol. 26). Cambridge, MA: Academic Press.

- [34] Nordhausen, B., & Langley, P. (1990). An integrated approach to empirical discovery. In J. Shrager & P. Langley (Eds.), *Computational models of scientific discovery and theory formation*. San Mateo, CA: Morgan Kaufmann.
- [35] Langley, P., Wogulis, J., & Ohlsson, S. (1990). Rules and principles in automated cognitive diagnosis. In N. Fredericksen, R. Glaser, A. Lesgold, & M. G. Shafto (Eds.), *Diagnostic monitoring of skill and knowledge acquisition*. Hillsdale, NJ: Lawrence Erlbaum.
- [36] Kibler, D., & Langley, P. (1988). Machine learning as an experimental science. *Proceedings of the Third European Working Session on Learning* (pp. 81–92). Glasgow: Pittman.
- [37] Langley, P., & Jones, R. (1988). A computational model of scientific insight. In R. Sternberg (Ed.), *The nature of creativity*. Cambridge University Press.
- [38] Langley, P., Bradshaw, G. L., & Simon, H. A. (1987). Heuristics for empirical discovery. In L. Bolc (Ed.), *Computational models of learning*. Berlin: Springer-Verlag.
- [39] Langley, P., & Carbonell, J. G. (1987). Language acquisition and machine learning. In B. MacWhinney (Ed.), *Mechanisms of language acquisition*. Hillsdale, NJ: Lawrence Erlbaum.
- [40] Langley, P., & Carbonell, J. G. (1987). Machine learning. In S. Shapiro (Ed.), *Encyclopedia of artificial intelligence*. New York: John Wiley & Sons.
- [41] Neches, R., Langley, P., & Klahr, D. (1987). Learning, development, and production systems. In D. Klahr, P. Langley, & R. Neches (Eds.), *Production system models of learning and development*. Cambridge, MA: MIT Press.
- [42] Langley, P. (1987). A general theory of discrimination learning. In D. Klahr, P. Langley, & R. Neches (Eds.), *Production system models of learning and development*. Cambridge, MA: MIT Press.
- [43] Ohlsson, S., & Langley, P. (1986). Psychological evaluation of path hypotheses in cognitive diagnosis. In H. Mandl & A. Lesgold (Eds.), *Learning issues for intelligent tutoring systems*. New York: Springer.
- [44] Langley, P., & Nordhausen, B. (1986). A framework for empirical discovery. *Proceedings of the International Meeting on Advances in Learning*. Les Arc, France.
- [45] Langley, P., Żytkow, J., Simon, H. A., & Bradshaw, G. L. (1986). The search for regularity: Four aspects of scientific discovery. In R. S. Michalski, J. G. Carbonell, & T. M. Mitchell (Eds.), *Machine learning: An artificial intelligence approach* (Vol. 2). San Mateo, CA: Morgan Kaufmann.
- [46] Fisher, D., & Langley, P. (1986). Methods of conceptual clustering and their relation to numerical taxonomy. In W. Gale (Ed.), *Artificial intelligence and statistics*. Reading, MA: Addison Wesley.
- [47] Langley, P., & Carbonell, J. G. (1984). Approaches to machine learning. *Journal of the American Society for Information Science*, 35, 306–316.
- [48] Langley, P., Bradshaw, G. L., & Simon, H. A. (1983). Rediscovering chemistry with the BACON system. In R. S. Michalski, J. G. Carbonell, & T. M. Mitchell (Eds.), *Machine learning: An artificial intelligence approach*. San Mateo, CA: Morgan Kaufmann.
- [49] Langley, P. (1983). Exploring the space of cognitive architectures. *Behavior Research Methods and Instrumentation*, 15, 289–299.
- [50] Langley, P., & Simon, H. A. (1981). The central role of learning in cognition. In J. R. Anderson (Ed.), *Cognitive skills and their acquisition*. Hillsdale, NJ: Lawrence Erlbaum.

### Workshop and Symposium Papers

- [1] Li, N., Stracuzzi, D., Cleveland, G., Langley, P., Konik, T., Shapiro, D., Ali, K., Molineaux, M., & Aha, D. (2009). Learning hierarchical skills for game agents from video of human behavior. *Proceedings of the IJCAI-09 Workshop on Learning Structural Knowledge from Observations*. Pasadena, CA.
- [2] Bridewell, W., & Langley, P. (2008). Processes and constraints in scientific model construction. *Proceedings of the Microsoft Research eScience Workshop*. Indianapolis, IN.

- [3] Langley, P., & Bridewell, W. (2008). Processes and constraints in explanatory scientific discovery. *Proceedings of the Thirtieth Annual Meeting of the Cognitive Science Society*. Washington, D.C.
- [4] Langley, P. (2007). Varieties of problem solving in a unified cognitive architecture. *Proceedings of the Twenty-Ninth Annual Meeting of the Cognitive Science Society*. Nashville, TN.
- [5] Asgharbeygi, N., Bay, S., Langley, P., & Arrigo, K. (2004). Computational revision of ecological process models. *Proceedings of the Fourth International Workshop on Environmental Applications of Machine Learning* (pp. 13–14). Bled, Slovenia.
- [6] Langley, P., & Messina, E. (2004). Experimental studies of integrated cognitive systems. *Proceedings of the Performance Metrics for Intelligent Systems Workshop*. Gaithersburg, MD.
- [7] Langley, P., Arai, S., & Shapiro, D. (2004). Model-based learning with hierarchical relational skills. *Proceedings of the ICML-2004 Workshop on Relational Reinforcement Learning*. Banff, Alberta.
- [8] Langley, P., Shapiro, D., Aycinena, M., & Siliski, M. (2003). A value-driven architecture for intelligent behavior. *Proceedings of the IJCAI-2003 Workshop on Cognitive Modeling of Agents and Multi-Agent Interactions* (pp. 10–18). Acapulco, Mexico.
- [9] Džeroski, S., & Langley, P. (2001). Computational discovery of communicable knowledge: Symposium report. *Proceedings of the Fourth International Conference on Discovery Science* (pp. 45–49). Washington, D.C.: Springer.
- [10] Rogers, S., Fiechter, C., & Langley, P. (1999). A route advice agent that models driver preferences. *Proceedings of the AAAI Spring Symposium on Agents with Adjustable Autonomy*. Stanford, CA: AAAI Press.
- [11] Ali, K. M., Langley, P., Maloof, M. A., Binford, T. O., & Sage, S. (1998). Improving rooftop detection with interactive visual learning. *Proceedings of the Image Understanding Workshop* (pp. 479–492). Monterrey, CA: Morgan Kaufmann.
- [12] Maloof, M. A., Langley, P., Binford, T. O., & Nevatia, R. (1998). Generalizing over aspect and location for rooftop detection. *Proceedings of the Fourth IEEE Workshop on Applications of Computer Vision* (pp. 194–199). Princeton, NJ: IEEE Press.
- [13] Kocabas, S., & Langley, P. (1998). Generating process explanations in nuclear astrophysics. *Proceedings of the ECAI-98 Workshop on Machine Discovery* (pp. 4–9). Brighton, UK.
- [14] Gervasio, M., Iba, W., & Langley, P. (1998). Case-based seeding for an interactive crisis response assistant. *Proceedings of the AAAI-98 Workshop on Case-Based Reasoning Integrations*. Madison, WI.
- [15] Gervasio, M., Iba, W., Langley, P., & Sage, S. (1998). Interactive adaptation for crisis response. *Proceedings of the AIPS-98 Workshop on Interactive and Collaborative Planning* (pp. 29–36). Pittsburgh.
- [16] Rogers, S., & Langley, P. (1998). Interactive refinement of route preferences for driving. *Proceedings of the AAAI Spring Symposium on Interactive and Mixed-Initiative Decision-Theoretic Systems* (pp. 109–113). Stanford, CA: AAAI Press.
- [17] Rogers, S., Langley, P., Johnson, B., & Liu, A. (1997). Personalization of the automotive information environment. *Proceedings of the Workshop on Machine Learning in the Real World: Methodological Aspects and Implications*. Nashville, TN.
- [18] Yamauchi, B., & Langley, P. (1996). Place learning in dynamic real-world environments. *Proceedings of RoboLearn-96: International Workshop for Learning in Autonomous Robots* (pp. 123–129). Key West.
- [19] Langley, P., & Sage, S. (1994). Pruning irrelevant features from oblivious decision trees. *Proceedings of the AAAI Fall Symposium on Relevance* (pp. 145–148). New Orleans: AAAI Press.
- [20] Thompson, K., Langley, P. (1992). Case studies in the use of background knowledge: Incremental concept formation. *Proceedings of the AAAI Workshop on Constraining Learning with Prior Knowledge* (pp. 60–68). San Jose, CA.
- [21] Allen, J. A., Langley, P., & Matwin, S. (1992). Knowledge and regularity in planning. *Proceedings of the AAAI Spring Symposium on Computational Considerations in Supporting Incremental Modification and Reuse* (pp. 7–12). Stanford, CA.

- [22] Thompson, K., Langley, P., & Iba, W. F. (1991). Using background knowledge in concept formation. *Proceedings of the Eighth International Workshop on Machine Learning* (pp. 554–558). Evanston, IL: Morgan Kaufmann.
- [23] Langley, P., & Allen, J. A. (1991). The acquisition of human planning expertise. *Proceedings of the Eighth International Workshop on Machine Learning* (pp. 80–84). Evanston, IL: Morgan Kaufmann.
- [24] Langley, P., McKusick, K. B., Allen, J. A., Iba, W. F., & Thompson, K. (1991). A design for the ICARUS architecture. *SIGART Bulletin*, 2, 104–109.
- [25] Billman, D., Fisher, D., Gluck, M., Langley, P., & Pazzani, M. (1990). Computational models of category learning. *Proceedings of the Twelfth Annual Conference of the Cognitive Science Society* (pp. 989–996). Cambridge, MA: Lawrence Erlbaum.
- [26] Thompson, K., & Langley, P. (1989). Incremental concept formation with composite objects. *Proceedings of the Sixth International Workshop on Machine Learning* (pp. 371–374). Ithaca: Morgan Kaufmann.
- [27] Allen, J. A., & Langley, P. (1989). Using concept hierarchies to organize plan knowledge. *Proceedings of the Sixth International Workshop on Machine Learning* (pp. 229–231). Ithaca, NY: Morgan Kaufmann.
- [28] Jones, R., & Langley, P. (1988). A theory of scientific problem solving. *Proceedings of the Tenth Annual Conference of the Cognitive Science Society* (pp. 244–250). Montreal, Quebec: Lawrence Erlbaum.
- [29] Langley, P., Gennari, J. H., & Iba, W. (1987). Hill-climbing theories of learning. *Proceedings of the Fourth International Workshop on Machine Learning* (pp. 312–323). Irvine, CA: Morgan Kaufmann.
- [30] Langley, P., Kibler, D., & Granger, R. (1986). Components of learning in a reactive environment. In T. M. Mitchell, J. G. Carbonell, & R. S. Michalski (Eds.), *Machine learning: A guide to current research*. Boston: Kluwer Academic Publishers.
- [31] Easterlin, J. D., & Langley, P. (1985). A framework for concept formation. *Proceedings of the Seventh Annual Conference of the Cognitive Science Society* (pp. 267–271). Irvine, CA.
- [32] Langley, P., Żytkow, J., Bradshaw, G. L., & Simon, H. A. (1983). Mechanisms for qualitative and quantitative discovery. *Proceedings of the Second International Workshop on Machine Learning* (pp. 121–132). Allerton, Illinois.
- [33] Sleeman, D., Langley, P., & Mitchell, T. (1982). Learning from solution paths: An approach to the credit assignment problem. *AI Magazine*, 3, 48–52.
- [34] Langley, P., Nicholas, D., Klahr, D., & Hood, G. (1981). A simulated world for modeling learning and development. *Proceedings of the Third Annual Conference of the Cognitive Science Society* (pp. 274–276). Berkeley, CA.

### Technical Reports

- [1] Shapiro, D., Billman, D., Marker, M., & Langley, P. (2004). *A human-centered approach to monitoring complex dynamic systems* (Technical Report). Institute for the Study of Learning and Expertise, Palo Alto, CA.
- [2] Langley, P., & Fehling, M. (1998). *The experimental study of adaptive user interfaces* (Technical Report 98-3). Institute for the Study of Learning and Expertise, Palo Alto, CA.
- [3] Langley, P. (1998). *Computational learning in humans and machines* (Technical Report 98-3). Institute for the Study of Learning and Expertise, Palo Alto, CA.
- [4] Yamauchi, B., Langley, P., Schultz, A. C., Grefenstette, J., & Adams, W. (1998). *MAGELLAN: An integrated adaptive architecture for mobile robotics* (Technical Report 98-2). Institute for the Study of Learning and Expertise, Palo Alto, CA.
- [5] Maloof, M. A., Langley, P., Binford, T. O., & Sage, S. (1998). *Improving rooftop detection in aerial images through machine learning* (Technical Report 98-1). Institute for the Study of Learning and Expertise, Palo Alto, CA.
- [6] Moriarty, D., & Langley, P. (1998). *Distributed learning of lane-selection strategies for traffic management* (Technical Report 98-2). Daimler-Benz Research & Technology Center, Palo Alto, CA.

- [7] Langley, P., Thompson, K., Iba, W. F., Gennari, J., & Allen, J. A. (1989). *An integrated cognitive architecture for autonomous agents* (Technical Report 89-28). Irvine: University of California, Department of Information & Computer Science.
- [8] Langley, P. (1986). *A cognitive architecture for learning in reactive environments* (Technical Report No. 86-21). Irvine: University of California, Department of Information & Computer Science.
- [9] Langley, P., Simon, H. A., Żytkow, J. M., & Fisher, D. H. (1985). *Discovering qualitative empirical laws* (Technical Report No. 85-18). Irvine: University of California, Department of Information & Computer Science.
- [10] Hall, R., Wenger, E., Kibler, D., & Langley, P. (1985). *The effect of multiple knowledge sources on learning and teaching* (Technical Report No. 85-11). Irvine: University of California, Department of Information & Computer Science.
- [11] Ohlsson, S., & Langley, P. (1985). *Identifying solution paths in cognitive diagnosis* (Technical Report No. CMU-RI-TR-85-2). Pittsburgh, PA: Carnegie-Mellon University, The Robotics Institute.
- [12] Langley, P., Ohlsson, S., & Sage, S. (1984). *A machine learning approach to student modeling* (Technical Report No. CMU-RI-TR-84-7). Pittsburgh, PA: Carnegie-Mellon University, The Robotics Institute.
- [13] Langley, P., & Neches, R. T. (1981). *PRISM user's manual* (Technical Report). Pittsburgh, PA: Carnegie-Mellon University, Department of Computer Science.
- [14] Langley, P. (1979). *A review of research on learning and discovery* (CIP Working Paper No. 415). Pittsburgh, PA: Carnegie-Mellon University, Department of Psychology.
- [15] Langley, P. (1979). *A computer model of learning from examples* (CIP Working Paper No. 400). Pittsburgh, PA: Carnegie-Mellon University, Department of Psychology.
- [16] Langley, P. (1978). *Towards a taxonomy of rule induction tasks* (CIP Working Paper No. 361). Pittsburgh, PA: Carnegie-Mellon University, Department of Psychology.

### Editorials and Commentaries

- [1] Langley, P. (2004). Cognitive architectures and the construction of intelligent agents. *Proceedings of the AAAI-2004 Workshop on Intelligent Agent Architectures* (pp. 82). Stanford, CA.
- [2] Langley, P. (2002). Lessons for the computational discovery of scientific knowledge. *Proceedings of First International Workshop on Data Mining Lessons Learned* (pp. 9-12). Sydney.
- [3] Langley, P., Magnani, L., Cheng, P. C.-H., Gordon, A., Kocabas, S., & Sleeman, D. H. (2001). Computational models of historical scientific discoveries. *Proceedings of the Twenty-Third Annual Conference of the Cognitive Science Society* (p. 3). Edinburgh: Lawrence Erlbaum.
- [4] Langley, P. (2000). Crafting papers on machine learning. *Proceedings of the Seventeenth International Conference on Machine Learning* (pp. 1207-1211). Stanford, CA: Morgan Kaufmann.
- [5] Langley, P. (2000). The maturing science of machine learning. *Proceedings of the Seventeenth International Conference on Machine Learning* (pp. xi-xii). Stanford, CA: Morgan Kaufmann.
- [6] Langley, P., Provan, G. M., & Smyth, P. (1997). Learning with probabilistic representations. *Machine Learning*, 29, 91-101.
- [7] Langley, P., & Shafto, M. G. (1997). Expanding our mental horizons. *Proceedings of the Nineteenth Annual Conference of the Cognitive Science Society* (pp. xxi-xxii). Mahwah, NJ: Lawrence Erlbaum.
- [8] Langley, P. (October, 1996). Relevance and insight in experimental studies. *IEEE Expert*, 11-12.
- [9] Langley, P. (Fall, 1996). Empirical methods in artificial intelligence: A review. *AI Magazine*, 95.
- [10] Langley, P. (1995). Stages in the process of scientific discovery. *Proceedings of the AAAI Spring Symposium on Systematic Methods for Scientific Discovery* (p. 93). Stanford, CA: AAAI Press.
- [11] Bowyer, K. W., Hall, L. O., Langley, P., Bhanu, B., & Draper, B. A. (1994). Report of the AAAI Fall Symposium on Machine Learning and Computer Vision: What, Why and How. *Proceedings of the Image Understanding Workshop* (pp. 727-731). Monterrey, CA. Morgan Kaufmann.

- [12] Langley, P. (1994). Selection of relevant features in machine learning. *Proceedings of the AAAI Fall Symposium on Relevance* (pp. 140–144). New Orleans: AAAI Press.
- [13] Langley, P. (1991). Machine learning and language acquisition. *Proceedings of the AAAI Spring Symposium on Machine Learning of Natural Language and Ontology*. Stanford, CA: AAAI Press.
- [14] Langley, P., & Drummond, M. (1990). Toward an experimental science of planning. *Proceedings of the 1990 DARPA Workshop on Innovative Approaches to Planning, Scheduling, and Control* (pp. 109–114).
- [15] Langley, P. (1990). Advice to authors of machine learning papers. *Machine Learning*, 5, 233–237.
- [16] Langley, P. (1990). Approaches to learning and representation. *Behavioral and Brain Sciences*.
- [17] Langley, P. (1989). Unifying themes in empirical and explanation-based learning. *Proceedings of the Sixth International Workshop on Machine Learning*. Ithaca, NY: Morgan Kaufmann.
- [18] Langley, P. (1989). Toward a unified science of machine learning. *Machine Learning*, 3, 253–259.
- [19] Langley, P. (1988). Structure and process in schema-based architectures. *Behavioral and Brain Sciences*.
- [20] Langley, P. (1988). Induction and explanation: Complementary models of learning. *Behavioral and Brain Sciences*.
- [21] Langley, P. (1988). Machine learning as an experimental science. *Machine Learning*, 3, 5–8.
- [22] Langley, P. (1987). The emerging science of machine learning. *Proceedings of the Fourth International Workshop on Machine Learning* (pp. 5–6). Irvine, CA: Morgan Kaufmann.
- [23] Langley, P. (1987). Research papers in machine learning. *Machine Learning*, 2, 195–198.
- [24] Langley, P. (1987). Machine learning and concept formation. *Machine Learning*, 2, 99–102.
- [25] Langley, P. (1987). Machine learning and grammar induction. *Machine Learning*, 2, 5–8.
- [26] Langley, P. (1986). Machine learning and discovery. *Machine Learning*, 1, 363–366.
- [27] Langley, P. (1986). Human and machine learning. *Machine Learning*, 1, 243–248.
- [28] Langley, P. (1986). The terminology of machine learning. *Machine Learning*, 1, 141–144.
- [29] Langley, P. (1986). On machine learning. *Machine Learning*, 1, 5–10.