

## Edith Law

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### CURRENT EMPLOYMENT

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#### University of Waterloo (Waterloo, ON)

*Associate Professor, David R. Cheriton School of Computer Science* (since July 2020)

*Assistant Professor, David R. Cheriton School of Computer Science* (2014-2020)

\* From November 1, 2016 – September 1, 2017, I was on a 10-month maternity leave.

### EDUCATION AND PROFESSIONAL PREPARATION

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#### Harvard University (Cambridge, MA) (2012-2014)

*Postdoctoral Researcher, School of Engineering and Applied Sciences*

#### Carnegie Mellon University (Pittsburgh, PA) (2006-2012)

*PhD in Machine Learning* (2012)

Advisors: Luis von Ahn (Computer Science) and Tom Mitchell (Machine Learning)

Dissertation: *Attribute Learning using Joint Human and Machine Computation*

#### McGill University (Montreal, QC) (2003-2005)

*M.Sc. in Computer Science* (2005)

Advisor: Doina Precup

Dissertation: *Risk-Directed Exploration in Reinforcement Learning*

#### University of British Columbia (Vancouver, BC) (1995-2000)

*B.Sc. in Computer Science* (2000)

Advisor: Maria Klawe

### MAJOR HONORS AND AWARDS

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Best paper honorable mention award at ACM DIS Conference (2022)

Best paper honorable mention award at ACM CHI Conference (2021)

Graham Research Fellow 2020-2022 (2020)

Best paper award at ACM CSCW Conference (2018)

Best paper honorable mention award at ACM CHI Conference (2016)

Harvard Center for Research on Computation and Society Fellowship (2012-2014)

AAMAS Challenges and Visions Track, Best Paper Second Prize (2013)

Best paper honorable mention award at ACM CHI Conference (2012)

FQRNT Postdoctoral Fellowship (Declined) (2012-2014)

Microsoft Graduate Research Fellowship (2009-2011)

Best paper honorable mention award at ACM CHI Conference (2009)

Robin Popplestone Fellowship, UMass Amherst (Declined) (2006)

NSERC Postgraduate Scholarship PGSD3 (Declined) (2006-2009)

## FUNDING

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- PI, “Developing Curriculum and Guidelines for A New Approach of Teaching and Learning Programming with Comics”** (2022)  
University of Waterloo Learning Innovation and Teaching Enhancement (LITE) Full Grant  
Awarded: \$7,500 CAD Total
- PI, “Curiosity-driven learning and personalized (re-)education technologies across the lifespan”** (2019)  
Waterloo-Bordeaux Joint Grant  
Awarded: €20,000 Total  
With Pierre-Yves Oudeyer (Inria, Bordeaux)
- PI, “Teachable Robot for Enhancing Student Curiosity and Learning”** (2019)  
University of Waterloo Interdisciplinary Trailblazer Grant  
Awarded: \$80,000 CAD total  
With Elizabeth Nilsen (Psychology, University of Waterloo)
- PI, “Promoting Meaningful Learning in Computer Science Courses by Leveraging Concreteness Fading”** (2019)  
University of Waterloo Learning Innovation and Teaching Enhancement (LITE) Full Grant  
Awarded: \$21,226.48 CAD Total
- Co-PI, “Public Engagement in Research: Exploring Participatory Research Labor and Employment Roles, Motivations, and Outcomes”** (2018)  
SSHRC Insight Development Grant  
Awarded: \$57,988 CAD Total  
With Zack Marshall (School of Social Work, McGill University)
- PI, “Doctoral Symposium for HCOMP 2019”** (2019)  
Artificial Intelligence Journal (AIJ) Grant for Promoting AI Research  
Awarded: €9000 Total  
With Jenn Wortman Vaughan (Microsoft Research) and Walter Lasecki (School of Information, University of Michigan)
- PI, “Curiosity-Driven Learning”** (2018)  
French Embassy in Canada: Mobility Funding for Researchers  
Awarded: €1100 Total
- PI, “Designing for Curiosity in Physical Spaces”** (2017)  
Waterloo-Bordeaux Joint Grant  
Awarded: €15,000 Total  
With Dana Kulic (ECE University of Waterloo), Pierre-Yves Oudeyer, Martin Hachet, Fabien Lotte (Inria, Bordeaux)
- PI, “CrowdCurio: Infrastructure for Research-Oriented Crowdsourcing”** (2016)  
Canadian Foundation for Innovation (CFI-JELF) and Ontario Research Funds (ORF)  
Awarded: \$110,000 CAD Total
- PI, “Doctoral Symposium for HCOMP 2016”** (2016)  
Artificial Intelligence Journal (AIJ) Grant for Promoting AI Research  
Awarded: €3000 Total  
With Haoqi Zhang (EECS, Northwestern University)

**co-PI, “SWaGUR: The Saskatchewan-Waterloo Games User Research Initiative”** (2016-2021)  
NSERC CREATE Grant  
Awarded: \$2,450,000 CAD Total  
With PIs Mark Hancock (Management Sciences, University of Waterloo) and  
Regan Mandryk (CS, University of Saskatchewan)

**PI, “A Framework for Hybrid Machine and Human Computation for the Accurate  
and Scalable Analysis of Human Clinical EEG Recordings”** (2015-2019)  
NSERC-CIHR Collaborative Health Project (CHRP) Grant  
Awarded: \$435,000 CAD Total  
With Joelle Pineau (CS, McGill University), Andrew Lim (Neurology, Sunnybrook Hospital)

**PI, “Driven by Curiosity: Interaction Techniques and Incentive Mechanisms for  
Crowdsourcing Scientific Tasks”** (2015-2020)  
NSERC Discovery Grant  
Awarded: \$115,000 CAD Total

**co-PI, “Waterloo/Twente Partnership to Accelerate Research in Data Driven  
Persuasive Health”** (2015)  
International Research Partnership (IRPG) Grant  
Awarded: \$55,000 CAD Total  
With PI Catherine Burns (System Design Engineering, University of Waterloo)

**“Effectively Leveraging Contributions in Human Computation Systems”** (2010-2013)  
NSF Social-Computational Systems SoCS Grant  
Awarded: \$737,500 USD Total  
With PIs Luis von Ahn (CS, Carnegie Mellon University) and Tom Mitchell  
(Machine Learning, Carnegie Mellon University)

## **PUBLICATIONS**

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N.B. Students directly under my supervision marked with \*. My name is listed last on papers where I am the lead PI.

### **Books**

B.1 **E. Law** and L. von Ahn. *Human Computation*. Morgan and Claypool Synthesis Lectures on Artificial Intelligence and Machine Learning, 2011, pages 1-121.

### **Book Chapters**

B.2 **E. Law**. Human Computation for Music Classification. In Li, T., Ogihara, M., Tzanetakis, G. ed. *Music Data Mining*, CRC Press/Chapman Hall, 2011, pages 281—301.

### **Refereed Journal Articles (In Computer Science)**

J.1 N. Chibber\*, J. Goh and **E. Law**. Teachable Conversational Agents for Crowdtwork: Effects on Performance and Trust. In CSCW 2022.

J.2 R. Abdelghani\*, P-Y. Oudeyer, **E. Law**, C. de Vulpillieres, H. Sauzeon. Conversational agents for fostering curiosity-driven behaviors in children. In International Journal of Human-Computer Studies, 167, 2022, pages 1—39.

- J.3 K-J. Lee\*, A. Chauhan\*, J. Goh, E. Nilsen and **E. Law**. Curiosity Notebook: The Design of a Research Platform for Learning by Teaching. In *Proceedings of the ACM on Human-Computer Interaction: Computer-Supported Cooperative Work and Social Computing*, CSCW (2022): pages 1-26.
- J.4 J. Ceha\*, D. Kulic, P-Y Oudeyer, D. Roy, and **E. Law**. Identifying Functions and Behaviours of Social Robots for In-Class Learning Activities: Teachers' Perspective. In *International Journal of Social Robotics*, 2021
- J.5 A. Williams\*, G. Mark, K. Milland, E. Lank and **E. Law**. The Perceptual Work Life of Crowdworkers: How Tooling Practices Increase Fragmentation in Crowdsourcing. In *Proceedings of the ACM on Human-Computer Interaction: Computer-Supported Cooperative Work and Social Computing*, CSCW (2019): pages 1-27.
- J.6 M. Schaekermann\*, G. Beaton\*, M. Habib, A. Lim, K. Larson and **E. Law**. Understanding Expert Disagreement in Medical Data Analysis through Structured Adjudication. In *Proceedings of the ACM on Human-Computer Interaction: Computer-Supported Cooperative Work and Social Computing*, CSCW (2019): pages 1-22.
- J.7 G. d'Eon\*, J. Goh, K. Larson and **E. Law**. Paying Crowd Workers for Collaborative Work. In *Proceedings of the ACM on Human-Computer Interaction: Computer-Supported Cooperative Work and Social Computing*, CSCW (2019): pages 1-24.
- J.8 M. Schaekermann\*, J. Goh, K. Larson and **E. Law**. Resolvable vs. Irresolvable Disagreement: A Study on Worker Deliberation in Crowdsourcing. In *Proceedings of the ACM on Human-Computer Interaction, vol. 2: Computer-Supported Cooperative Work and Social Computing*, CSCW (2018): 154, pages 1-19. **(Best Paper Award)**
- J.9 W. Challaghan\*, J. Goh, M. Mohareb, A. Lim and **E. Law**. MechanicalHeart: A Human-Machine Framework for the Classification of Phonocardiograms. In *Proceedings of the ACM on Human-Computer Interaction, vol. 2: Computer-Supported Cooperative Work and Social Computing*, CSCW (2018): 28, pages 1-17.
- J.10 M. Cartwright, A. Seals, J. Salamon, A. Williams\*, S. Mikloska\*, D. MacConnell, **E. Law**, J.P. Bello, O. Nov. Seeing Sound: Investigating the Effects of Visualizations and Complexity on Crowdsourced Audio Annotations. In *Proceedings of the ACM on Human-Computer Interaction, vol. 1: Computer-Supported Cooperative Work and Social Computing*, CSCW (2017): 29, pages 1-21.

#### Refereed Journal Articles (Outside Computer Science)

N.B.: These are journal publications that resulted from our crowdsourcing systems (CrowdCurio, CrowdEEG) being used by medical and biology scientists to crowdsource annotation of research data.

- J.11 E. Sokolov, D. Abdoul Bachir, F. Sakadi, J.A. Williams, A. Vogel, M. Schaekermann\*, N.R. Tassiou, K.A. Bah, V. Khatri, G.C. Hotan, N. Ayub, E.C.W. Leung, T.A. Fantaneanu, A. Patel, M. Vyas, T. Milligan, M. Villamar, D. Hoch, S. Purves, B. Esmaili, M. Stanley, T. Lehn-Schioler, J. Tellez-Zenteno, E. Gonzalez-Giraldo, I. Tolokh, L. Heidarian, L. Worden, N. Jadeja, S. Fridinger, L. Lee, **E. Law**, C. Fodé Abass, F.J. Mateen. Tablet-based EEG diagnostics for epilepsy patients in the West African Republic of Guinea. In *European Journal of Neurology*, 2020.
- J.12 M. Schaekermann\*, N. Hammel, M. Terry, T. Ali, Y. Liu, B. Basham, B. Campana, W. Chen, X. Ji, J. Krause, G. Corrado, L. Peng, D. Webster, **E. Law**, and R. Sayres. Remote Tool-based Adjudication for Grading Diabetic Retinopathy. In *Translational Vision Science & Technology (TVST)*, 8(6): 40, 2019.

- J.13 J. Williams, F.A. Cisse, M. Schaekermann\*, F. Sakadi, N.R. Tassiou, G.C. Hotan, A.K. Bah, A. Hamani, A. Lim, E.C.W. Leung, T.A. Fantaneanu, T.A. Milligan, V. Khatri, D.B. Hoch, M.V. Vyas, A.D. Law, J.M. Cohen, A.C. Vogel, **E. Law**, F.J. Mateen. Smartphone EEG and Remote Online Interpretation for Children with Epilepsy in the Republic of Guinea: Quality, Characteristics and Practical Implications. In *Seizure: European Journal of Epilepsy*: 71, 2019, pages 1-7.
- J.14 D. Park, I. Breckheimer, A. Williams\*, **E. Law**, A. Ellison and C. Davis. Herbarium specimens reveal substantial and unexpected variation in phenological sensitivity across the eastern United States. In *Philosophical Transactions of the Royal Society B: Biological Sciences*, 374, 2018, pages 1–12.
- J.15 C. Willis, **E. Law**, A. Williams\*, B. Franzone, R. Bernardos, L. Bruno, C. Hopkins, C. Schorn, E. Weber, D. Park and C. Davis. CrowdCurio: an online crowdsourcing platform to facilitate climate change studies using herbarium specimens. In *New Phytologist*, 215(1), 2017, pages 479-488.
- J.16 M.A. O’Leary, K. Alphonse, A.H. Mariangeles, D. Cavaliere, A. Cirranello, T. Dietterich, M. Julius, S. Kaufman, **E. Law**, M. Passarotti, J. Robalino, N. Simmons, S. Smith, D. Stevenson, E. Theriot, P. Velazco, R. Walls, M. Yu, M. Daly. Crowd replicate performance of scientific experts scoring phylogenetic matrices of phenotypes. In *Systematic Biology*, 67(1), 2017, pages 49-60.
- J.17 J.G. Burleigh, K. Alphonse, A.J. Alverson, H.M. Bik, C Blank, A.L. Cirranello, H. Cui, M. Daly, T.G. Dietterich, G. Gasparich, J. Irvine, M. Julius, S. Kaufman, **E. Law**, J. Liu, L. Moore, M.A. O’Leary, M. Passarotti, S. Ranade, N.B. Simmons, D.W. Stevenson, R.W. Thacker, E.C. Theriot, S. Todorovic, P.M. Velazco, R.L. Walls, J.M. Wolfe, M. Yu. Next-generation phenomics for the Tree of Life. *PLoS Curr.* 2013 Jun 26, 5.

#### Refereed Conference Papers

- C.1 S. Suh\*, J. Zhao and **E. Law**. CodeToon: Authoring Tool for Creating Comics from Code with Story Ideation and Automatic Comic Generation. In *UIST 2022*.
- C.2 J. Ceha\* and **E. Law**. Expressive Auditory Gestures in a Voice-Based Pedagogical Agent. In *CHI 2022*.
- C.3 S. Suh\*, S. Lamorea, **E. Law** and L. Zhang-Kennedy. PrivacyToon: The Design and Evaluation of a Comic-Based Authoring Tool with Creativity Support for Privacy Concepts. In *DIS 2022*. (**Best Paper Honorable Mention**)
- C.4 P.B. Ravari\*, K-J Lee\*, **E. Law** and D. Kulic. Effects of an Adaptive Robot Encouraging Teamwork on Students' Learning. In *IEEE International Conference on Robot and Human Interactive Communication (ROMAN)*, 2021.
- C.5 J. Ceha\*, K. J. Lee\*, E. Nilsen, J. Goh and **E. Law**. Can a Humorous Conversational Agent Enhance Learning Experience and Outcomes? In *CHI 2021*. (**Best Paper Honorable Mention**)
- C.6 S. Suh\*, K.J. Lee\*, B. Cheng\*, C. Latulipe and **E. Law**. Using Comics to Introduce and Reinforce Programming Concepts in CS1. In *SIGCSE 2021*.
- C.7 A. Vtyurina\*, C. Clarke, **E. Law**, J. Trippas and H. Bota. A Mixed-Method Analysis of Text and Audio Search Interfaces with Varying Task Complexity. In *ACM ICTIR 2020*.
- C.8 \*S. Suh, M. Lee, \*G. Xia and **E. Law**. Coding Strip: A Pedagogical Tool for Teaching and Learning Programming Concepts through Comics. In *IEEE VL/HCC 2020*.

- C.9 H. Chen\*, K. Czarnecki, R. Cohen, K. Dautenhahn, **E. Law**. Autonomous Vehicle Visual Signals for Pedestrians: Experiments and Design Recommendations. In *IEEE Intelligent Vehicles Symposium (IV) 2020*.
- C.10 S. Suh\*, M. Lee and **E. Law**. How Do We Design for Concreteness Fading? Survey, General Framework, and Design Dimensions. In *IDC 2020*.
- C.11 M. Alaimi\*, **E. Law**, K. Pantasdo\*, P-Y. Oudeyer and H. Sauzeon. Pedagogical Agents for Fostering Question-Asking Skills in Children. In *Proceedings of the CHI Conference on Human Factors in Computing Systems, CHI '20, 2020*, pages 1-12.
- C.12 M. Schaekermann\*, G. Beaton\*, E. Sanoubari, A. Lim, K. Larson and **E. Law**. Ambiguity-aware AI Assistants for Medical Data Analysis. In *Proceedings of the CHI Conference on Human Factors in Computing Systems, CHI '20, 2020*, pages 1-11.
- C.13 N. Dillen, M. Ilievski, **E. Law**, L. Nacke, K. Czarnecki and O. Schneider. Keep Calm and Ride Along: Passenger Comfort and Anxiety as Physiological Responses to Autonomous Driving Styles. In *Proceedings of the CHI Conference on Human Factors in Computing Systems, CHI '20, 2020*, pages 1-12.
- C.14 J. Ceha\*, N. Chhibber\*, J. Goh, P-Y Oudeyer, C. McDonald, D. Kulic, **E. Law**. Expression of Curiosity in Social Robots: Design, Perception, and Effects on Behaviour. In *Proceedings of the CHI Conference on Human Factors in Computing Systems, CHI '19, 2019*, pages 1-12.
- C.15 A. Williams\*, J. Goh, C. Willis, A. Ellison, J. Brusuelas, C. Davis and **E. Law**. Deja Vu: Characterizing Worker Reliability Using Task Consistency. In *Proceedings of the AAAI Conference on Human Computation and Crowdsourcing, HCOMP '17, 2017*, pages 197-205.
- C.16 **E. Law**, V. Cai\*, E. Liu\*, S. Sasy\*, J. Goh, A. Blidaru\* and D. Kulic. A Wizard-of-Oz Study of Curiosity in Human-Robot Interaction. In *Proceedings of the IEEE International Symposium on Robot and Human Interactive Communication, RO-MAN '17, 2017*, pages 1-8.
- C.17 P. Jaini, Z. Chen, P. Carbajal, **E. Law**, L. Middleton, K. Regan, M. Schaekermann\*, G. Trimponias, J. Tung, and P. Poupart. Online Bayesian Transfer Learning for Sequential Data Modeling. In *Proceedings of the 5th International Conference on Learning Representations, ICLR '17, 2017*, pages 1-20.
- C.18 **E. Law**, K. Z. Gajos, A. Wiggins, M. Gray and A. Williams\*. Crowdsourcing as a Tool for Research: Implications of Uncertainty. In *Proceedings of the ACM Conference on Computer-Supported Cooperative Work and Social Computing, CSCW '17, 2017*, pages 1-18.
- C.19 T. Tse\*, J. Salamon, A. Williams\*, H. Jiang\* and **E. Law**. Ensemble: A Hybrid Human-Machine System for Generating Melody Scores from Audio. In *Proceedings of the International Conference on Music Information Retrieval, ISMIR '16, 2016*, pages 1-7.
- C.20 S. Pan\*, K. Larson, J. Bradshaw\* and **E. Law**. Dynamic Task Allocation Algorithm for Hiring Workers that Learn. In *Proceedings of the International Joint Conference on Artificial Intelligence, IJCAI '16, 2016*, pages 1-7.
- C.21 **E. Law**, M. Yin, J. Goh, K. Chen\*, M. Terry and K.Z. Gajos. Curiosity Killed the Cat, but Makes Crowdwork Better. In *Proceedings of the CHI Conference on Human Factors in Computing Systems, CHI '16, 2016*, pages 1-13. (**Best Paper Honorable Mention**)
- C.22 O. Amir, B. Grosz, **E. Law** and R. Stern. Collaborative Health Plan Support. In *Proceedings of the International Conference on Autonomous Agents and Multiagent Systems, AAMAS '13, 2013*, pages 793-796. (**Best Paper Second Prize, Challenges and Visions Track**)

- C.23 H. Zhang, **E. Law**, K.Z. Gajos, E. Horvitz, R.C. Miller and D. Parkes. Human Computation Tasks with Global Constraints: A Case Study. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, CHI '12, 2012, pages 1-10. (**Best Paper Honorable Mention**)
- C.24 **E. Law** and H. Zhang. Towards Large-Scale Collaborative Planning: Answering High-Level Search Queries Using Human Computation. In *Proceedings of the AAAI Conference on Artificial Intelligence*, AAAI '11, 2011, pages 1-6.
- C.25 **E. Law**, B. Settles and T. Mitchell. Learning to Tag using Noisy Labels. In *Proceedings of the European Conference on Machine Learning*, ECML '10, 2010, pages 1-16.
- C.26 **E. Law**, K. West, M. Mandel, M. Bay and S. Downie. Evaluation of Algorithms Using Games: The Case of Music Tagging. In *Proceedings of the International Conference on Music Information Retrieval*, ISMIR '09, 2009, pages 1-6.
- C.27 **E. Law** and L. von Ahn. Input-agreement: A New Mechanism for Data Collection using Human Computation Games. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*, CHI '09, 2009, pages 1-10. (**Best Paper Honorable Mention**)

#### Refereed Short Papers and Extended Abstract

- P.1 **E. Law**, P. Baghaei\*, N. Chhibber\*, D. Kulic, S. Lin\*, K. D. Pantasdo\*, J. Ceha\*, S. Suh\*, N. Dillen\*. Curiosity Notebook: A Platform for Learning by Teaching Conversational Agents. In *CHI 2020 Late Breaking Work*.
- P.2 J. Williams, F.A. Cisse, M. Schaekermann\*, F. Sakadi, N.R. Tassiou, A.K. Bah, A.B.D. Hamani, A. Lim, E.C.W. Leung, T.A. Fantaneau, T. Milligan, V. Khatri, D. Hoch, M. Vyas, A. Lam, G. Hotan, J. Cohen, **E. Law** and F. Mateen. (2019). Utilizing a wearable smartphone-based EEG for pediatric epilepsy patients in the resource poor environment of Guinea: A prospective study. In *Annual Meeting of the American Academy of Neurology (AAN) 2019*, pages 1.
- P.3 C. Vandenhof\* and **E. Law**. Contradict the Machine: A Hybrid Approach to Identifying Unknown Unknowns. In *Proceedings of the 18<sup>th</sup> International Conference on Autonomous Agents and Multiagent Systems*, AAMAS '19, 2019, pages 2238-2240.
- P.4 **E. Law**, C. Dalton\*, N. Merrill\*, A. Young\*, K.Z. Gajos. CrowdCurio: A Platform for Supporting Mixed-Expertise Crowdsourcing. In *Proceedings of the AAAI Conference of Human Computation and Crowdsourcing*, HCOMP '13, 2013, pages 1-2.
- P.5 **E. Law**, P. Bennett and E. Horvitz. The Effects of Choice in Routing Relevance Judgments. In *Proceedings of the ACM SIGIR Conference on Research and Development in Information Retrieval*, SIGIR '11, 2011, pages 1-2.
- P.6 **E. Law**, A. Mityagin and M. Chickering. Intentions: A Game for Classifying Search Query Intent. In *Proceedings of the CHI Conference on Human Factors in Computing Systems Work-In-Progress*, CHI '09, 2009, pages 1-4.
- P.7 **E. Law**, L. von Ahn, R. Dannenberg and M. Crawford. TagATune: a Game for Sound and Music Annotation. In *Proceedings of the International Conference on Music Information Retrieval*, ISMIR '07, 2007, pages 1-4.

#### Refereed Workshop Articles

- W.1 G. Melo\*, **E. Law**, P. Alencar and D. Cowan. Understanding User Understanding: What do Developers Expect from a Cognitive Assistant? In *IEEE BigData Workshop 2020*.

- W.2 N. Chhibber\* and **E. Law**. Teaching Conversational Agents. In *NeurIPS 2020 Workshop on Human-in-the-Loop Dialog Systems*.
- W.3 A. Appriou\*, J. Ceha\*, S. Pramij, D. Dutartre, **E. Law**, P-Y Oudeyer and F. Lotte. Towards measuring states of epistemic curiosity through electroencephalographic signals. In *Proceedings of the IEEE International Conference on Systems, Man and Cybernetics (SMC '20)*, 2020.
- W.4 **E. Law**, K.J. Lee\* and P. Baghaei\*. The Curiosity Notebook: A Platform for Supporting Learning with Teachable Robots. In *HRI 2020 Workshop on Exploring Creative Contents in Social Robots*.
- W.5 **E. Law**, E. Nilsen, K.J. Lee\*, A. Chauhan\*, J. Ceha\*, P. Baghaei\*, A. Debbane\* and K. Yang\*. Learning and Teaching with Conversational Agents. In *CHI 2020 Workshop on Grand Challenges in Conversational UI*.
- W.6 **E. Law** and L. Kuang\*. The Role of Experimentation in Human-AI Interaction. In *Proceedings of CHI Workshop on Where is the Human? Bridging the Gap between AI and HCI, 2019*, pages 1-5.
- W.7 **E. Law** and D. Kulic. How to Know When a User is Curious: A Challenge for HRI in Social Robotics. In *Proceedings of CHI Workshop on The Challenges of Working with Social Robots that Collaborate with People, 2019*, pages 1-6.
- W.8 A. Williams\*, H. Kaur, **E. Law** and E. Lank. Guiding Attention with Tasks and Emotions in Conversational Agents. In *Proceedings of CHI Workshop on Conversational Agents: Constructing Action Plans from a Wave of Research and Development, 2019*, pages 1-8.
- W.9 N. Chhibber\* and **E. Law**. Using Conversational Agents to Support Learning by Teaching. In *Proceedings of CHI Workshop on Conversational Agents: Constructing Action Plans from a Wave of Research and Development, 2019*, pages 1-7.
- W.10 N. Dilen\*, **E. Law**, O. Schneider and K. Czarnecki. Passenger-vehicle Interaction in Fully Autonomous Vehicles: current and future trends. In *Proceedings of CHI Workshop on Looking into the Future: Weaving the Threads of Vehicle Automation, 2019*, pages 1-5.
- W.11 G. d'Eon\*, K. Larson and **E. Law**. The Effects of Single-Player Coalitions on Reward Divisions in Cooperative Games. In *Proceedings of AAMAS Games, Agents and Incentives Workshop, 2019*, pages 1-15.
- W.12 M. Schaekermann\*, G. Beaton\*, M. Habib, A. Lim, K. Larson and **Law, E.** (2019). CrowdEEG: A Platform for Structured Consensus Formation in Medical Time Series Analysis. In *Proceedings of the CHI 8th Workshop on Interactive Systems in Healthcare (WISH), 2019*, pages 1-4.
- W.13 M. Schaekermann\*, G. Beaton\*, M. Habib, A. Lim, K. Larson and **E. Law**. Capturing Expert Arguments from Medical Adjudication Discussions in a Machine-readable Format. In *Proceedings of the WebConf Workshop on Subjectivity, Ambiguity and Disagreement (SAD) on the Web, 2019*, pages 1-7.
- W.14 M. Schaekermann\*, **E. Law**, K. Larson, K. and A. Lim. Expert Disagreement in Sequential Labeling: A Case Study on Adjudication in Medical Time Series Analysis. In *Proceedings of the HCOMP Workshop on Subjectivity, Ambiguity and Disagreement (SAD) in Crowdsourcing, 2018*, pages 1-7.
- W.15 N. Chhibber\*, R. Syed, M. Teng, J. Goh, K. Collins-Thompson and **E. Law**. Human Perception of Surprise: A User Study. In *Proceedings of SIGIR Computational Surprise Workshop, 2018*, pages 1-4.



- W.16 A. Williams\*, A. Vtyurina\*, E. Lank and **E. Law**. Designing Voice Interfaces for Accessible Crowdtwork. In *Proceedings of CSCW Workshop on Accessible Voice Interfaces, 2018*, pages 1-4.
- W.17 A. Vtyurina\*, A. Fournay and **E. Law**. 5 Seconds After: Exploring User Actions with Voice Assistants in the Moments After a System Response. In *Proceedings of CHI Workshop on Voice-based Conversational UX Studies and Design, 2018*, pages 1-5.
- W.18 A. Williams\*, J. Bradshaw\*, M. Schaekermann, T. Tse, W. Callaghan and **E. Law**. The Big Picture: Preserving Context in the Decomposition of Complex Expert Tasks. In *Proceedings of the CHI Productivity Decomposed Workshop, 2016*, pages 1-2.
- W.19 M. Schaekermann\*, **E. Law**, A. Williams\* and W. Callaghan\*. Resolvable vs Irresolvable Ambiguity: A new hybrid framework for dealing with uncertain ground truth. In *Proceedings of the CHI Workshop on Human-Centered Machine Learning, 2016*, pages 1-5.
- W.20 **E. Law**, B. Grosz, L.M. Sanders and S.H. Fischer. SimplyPut: Leveraging a Mixed-Expertise Crowd to Improve Health Literacy. In *Proceedings of the AAMAS Workshop on Human-Agent Interaction Design and Models, 2013*, pages 1-10.
- W.21 **E. Law**, B. Settles, A. Snook, H. Surana, L. von Ahn and T. Mitchell. Human Computation for Attribute and Attribute Value Acquisition. In *Proceedings of the CVPR Workshop on Fine-Grained Visual Categorization, 2011*, pages 1-2
- W.22 J. Betteridge, A. Carlson, S. Hong, E.Jr. Hruschka, **E. Law**, T. Mitchell, and S. Wang. Towards Never Ending Language Learning. In *Proceedings of the AAAI Spring Symposium on Learning by Reading and Learning to Read, 2009*, pages 1-2.
- W.23 **E. Law**, L. von Ahn and T. Mitchell. Search Wars: A Game for Improving Web Search. In *Proceedings of the Human Computation Workshop, 2009*, pages 31.
- W.24 **E. Law**. The Problem of Accuracy as An Evaluation Criterion. In *Proceedings of the ICML Workshop on Evaluation Methods for Machine Learning, 2008*, pages 1-4.

#### PATENTS

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1. D.M. Chickering, **E. Law**, A. Mityagin. Arrangement for building and operating human-computation and other games. US Patent 8137201, 2012.

#### INVITED TALKS

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##### Plenary talks

1. *Crowdsourcing Medical Time Series Annotation: Expertise, Ambiguity and Human-AI Collaboration*. Invited talk at TU Delft Academic Fringe Festival: Crowd Computing & Human-Centered AI, February 2020.
2. *Designing Interactive Systems to Elicit Curiosity*. Invited talk at Conference on Curiosity: Emerging Sciences and Educational Innovations, University of Pennsylvania, Philadelphia, December 2018.
3. *Crowd Computing*. Invited talk at ETH Zurich and Collegium Helveticum. Zurich, Switzerland. December 2017.
4. *The Case of Thoreau's Field Notes: How CrowdCurio Helps to Advance Science and Citizen Science*. Invited talk at HCI International Conference (HCII) 2017 Panel. Vancouver, BC. July 2017.
5. *Designing for Curiosity*. Invited talk at the International Conference on Graphics, Visualization and Human-Computer Interaction (GI). Victoria, BC. May 2016.
6. *Mixed Expertise Crowdsourcing*. Invited keynote at the ICML Workshop on "Machine Learning Meets Crowdsourcing". Atlanta, Georgia. June 2013.
7. *SimplyPut: A Crowdware System for Improving Health Communication and Literacy*. Invited talk at the Academic Pediatric Association Annual Meeting. May 2013.

### University colloquia

8. *Socio-technical Challenges in Scientific and Medical Crowdsourcing*. Invited talk at the Carnegie Mellon University HCII and LTI Crowdsourcing Seminar. April 2018.
9. *Designing for Curiosity*. Invited talk at the Toronto User Experience (TUX) Speaker Series. University of Toronto, ON. February 2016.
10. *Balancing Task-Centric and Human-Centric Objectives in Human Computation Systems*. Harvard Center for Research on Computation and Society. Cambridge, MA. September 2012.

### Tutorials

11. *Crowdsourcing as a Tool for Research and Public Engagement*. 5-day course at the Digital Humanities Summer Institute, University of Victoria, BC. June 2015.
12. *Human Computation: A Broad Perspective*. 4-hour tutorial at the ACM Intelligent User Interfaces (IUI) Conference. March 2013.
13. *Human Computation: Core Research Questions and State of the Art*. 4-hour tutorial at the AAAI Conference. March 2011.

### Industry talks

14. *What should User-Centered Design look like for AI/ML Systems?* Invited talk at Element AI, Toronto, June 2018
15. *The "What" and the "How": Two Studies of Curiosity-Inducing Interfaces*. Microsoft Research Redmond, Redmond, WA. July 2017.

### RESEARCH EXPERIENCE

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**Faculty Fellow, Element AI (Montreal, QC) (2017-present)**

**Research Intern, Microsoft Research (Redmond, WA) (summer 2010)**

*Mentors: Paul Bennett and Eric Horvitz*

**Research Intern, Microsoft Live Labs (Bellevue, WA) (summer 2008)**

*Mentor: Max Chickering*

**Research Intern, National Research Council (Ottawa, ON) (summer 1999)**

### PROFESSIONAL EXPERIENCE

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**AI Programmer, Ubisoft Entertainment Inc (Montreal, QC) (2005-2006)**

**Software Developer, IBM Canada (Vancouver, BC) (2000-2003)**

**Software Developer, Sony Inc. (Tokyo, Japan) (1998)**

### TEACHING

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**CS 889: Human-in-the-loop Systems (fall 2014, fall 2015)**

This *new* graduate course gives a broad overview of various models for combining human and machine intelligence to solve computational problems. Through weekly seminars and a class project, we examine three roles that humans play in computational systems -- humans as computers, humans as teachers, and humans as collaborators. This course covers both literature from HCI and AI, and the topics include human computation and crowdsourcing, learning by demonstration, mixed initiative systems, active learning from human teachers, and interactive machine learning.

*Student Evaluation: 4.2/5 (fall 2014), 4.5/5 (fall 2015)*

**CS 349: User Interfaces****(winter 2015)**

This course introduces contemporary user interfaces, including the basics of human-computer interaction, the user interface design/evaluation process, and the architectures within which user interfaces are developed. In 2015, I completely re-structured the course materials for CS349 to teach user interface concepts via web technology (i.e., HTML, CSS, Javascript).

*Student Evaluation: 3.7/5 (section 2), 3.8/5 (section 3)*

**CS 889: Human-AI Interaction****(winter 2018)**

AI and machine learning technologies has become increasingly integrated with our everyday lives. Yet, such systems are often complex, unpredictable and unfamiliar to users, making it difficult for them to understand, trust and adopt them. This *new* graduate course involves a survey of existing literature on Human-AI interaction, on topics such as safety, fairness, interpretability, ethics, trust, and human-in-the-loop computation. The course is also in part a methodology course---students study different HCI data collection (e.g., experiments, diary studies, interviews, etc.) and analysis (e.g., statistical modeling, grounded theory analysis, etc.) techniques and apply them to research questions related to Human-AI interaction. The coursework involves a weekly seminar and a course project.

*Student Evaluation: 4.3/5*

**CS 449: Human Computer Interaction****(spring 2018, fall 2019, spring 2020, spring 2021)**

Human-Computer Interaction teaches the fundamental issues that underlie the creation and evaluation of usable and useful computational artifacts. Over the term, students learn how to design novel computational artifacts that enable a well-defined user group to achieve specific goals more effectively. Students learn and directly apply: (1) Rapid ethnography, which includes learning how to perform interviews and in situ observations, (2) User-centered design techniques, including contextual design and low-fidelity, high-iteration prototyping practices (e.g., paper-based prototyping and Wizard-of-Oz studies), (3) Evaluation methods for measuring how a design compares to existing methods of accomplishing a task. The course involves lectures, in-class activities, assigned readings and group projects. In 2018, I restructured the course to be more akin to an interactive *studio*, where students work with instructors and TAs to critique design and refine prototypes in class.

*Student Evaluation: 4.2/5 (spring 2018)*

*Student Evaluation: 4.4/5 (fall 2019)*

**CS 480: Introduction to Machine Learning****(winter 2019)**

The course introduces students to the design of algorithms that enable machines to "learn". In contrast to the classic paradigm where machines are programmed by specifying a set of instructions that dictate what exactly a machine should do, a new paradigm is developed whereby machines are presented with examples from which they learn what to do. This is especially useful in complex tasks such as natural language processing, information retrieval, data mining, computer vision and robotics where it is not practical for a programmer to enumerate all possible situations in order to specify suitable instructions for all situations. Instead, a machine is fed with large datasets of examples from which it automatically learns suitable rules to follow. The course will introduce the basics of machine learning and data analysis, and cover human-centered machine learning issues, such as bias, interpretability and AI for social good.

*Student Evaluation: 3.9/5 (section 1), 3.7/5 (section 2)*

**CS 889: Conversational Agents****(winter 2020)**

Conversational Agents has become increasingly integrated with our everyday lives. This graduate course will explore recent HCI research on conversational agents. The course is also a methodology course---we will study different HCI methodologies (e.g., experiments, diary studies, interviews, etc) and analysis techniques (e.g., statistical modeling, grounded theory analysis) and apply them to research questions related to conversational agents. There are three main components: Paper Critique, Presentation, Project. The coursework involves a weekly seminar and a course project.

**CS 889: Masterclass in Human-Computer Interaction – Education Technology****(winter 2021)**

This course is called Masterclass in Human-Computer Interaction, in that students will learn how to conduct HCI research by doing and through critiques. Students study the process of HCI research: from formulating questions, selecting/using the appropriate research methodologies (e.g., experiments, diary

studies, interviews, etc), connecting the research to theories, analyzing data (e.g., statistical modeling, grounded theory analysis), to deriving design implications from the results. The research theme varies from year to year; for W21, the theme is Education Technology.

## **STUDENTS AND POSTDOCS SUPERVISION**

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### **Graduate/Thesis Supervision**

Ken Jen Lee (Ph.D.)	(2020 – present)
Jarvis Xie (M.Math)	(2022 – present)
Kris Frasherri (M.Math)	(2022 – present)
Nabil Bin Hannan (Ph.D.)	(2022 – present)

### **Graduate/Thesis Supervision (Graduated)**

Sangho Suh (Ph.D.)	(Postdoctoral Fellow, UCSD)
Jessy Ceha (Ph.D.)	(Scientific Editor, Elsevier)
Amy Gabriela Debbane (M.Math.)	(UX Researcher, Arctic Wolf)
Alexandra Vtyurina (Ph.D., co-advised with Charlie Clarke)	(Research Scientist, Kira Systems)
Mike Schaekermann* (Ph.D., co-advised with Kate Larson)	(Applied Scientist, Amazon)
Colin Vandenhof (M.Math)	(Graduated, Spiri Robotics)
Nalin Chhibber (M.Math.)	(Research Engineer at AutoDesk)
Alex Williams (Ph.D., co-advised with Ed Lank)	(Assistant Professor at U. Tennessee Knoxville)
Greg D'Eon (M.Math., co-advised with Kate Larson)	(Ph.D. student at UBC)
William Callaghan (M.Math.)	(Data Engineer, Borealis.AI Montreal)
Sundra Yunjia Sun (M.Math, co-advised with Ed Lank)	(Google Waterloo)
Tim Tse (M.Math., co-advised with Pascal Poupart)	

\*Mike Schaekermann has received the 2020 Cheriton Distinguished Dissertation Award as well as the 2020 Canadian Computer Science (CAN-CS) Distinguished Dissertation Award.

### **Postdoc Supervision**

Apoorva Chauhan	(2019 – 2021)
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### **Undergraduate Supervision**

Anthony Maocheia-Ricci	(2022)
Joice Tang (URF, University of British Columbia)	(2021)
Jason Liu (URA)	(2021)
Ken Jen Lee (URA/URF)	(2019)
Jarvis Xie (URA)	(2019)
Amy Gabriela Debbane (URA)	(2019)
Gracie Xia (URA)	(2018)
Kevin Pantasdo (URA)	(2018)
Steven Feng (URA)	(2018)
Linhai Ying (URA)	(2018)
Stephanie Lin (URA)	(2018)
Helga Jiang (URA, co-op)	(2017)
Meng Dong (URA, undergrad thesis)	(2017)
Stephanie Mikloska (URA)	(2016)
Clarice Ng (URA)	(2016)
Eddie Du (URA)	(2016)
Maoning Guo (URA)	(2016)
Jing Tao (URA)	(2016)
Mark Martinez (URA)	(2016)
Josh Bradshaw (research co-op)	(2015)
Tiasa Mondol (URA)	(2015)
Kevin Chen (URA)	(2015)
Charlie Wu (URA)	(2015)

Ruiming Zhu (URA)	(2014)
Rui Lin (URA)	(2014)
Wenchao Du (URA)	(2014)
Susu Dong (URA)	(2014)
Elkan Wang (URA)	(2014)

### Former Students

Louis Kuang (M.Math., co-advised with Kate Larson)	(Google Waterloo)
Kexin Yang (M.Math.)	(Ph.D student, Carnegie Mellon)

### INTERNAL THESIS EXAMINATION COMMITTEE

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Murat Dikmen (Ph.D. Thesis)	(2022)
Nikhita Vinod Joshi (Ph.D. Comprehensive)	(2022)
Glaucia Melo (Ph.D. Comprehensive)	(2020)
Kyle Robinson (Masters Thesis)	(2020)
Neil Budnarain (Masters Thesis)	(2020)
Alex Yun (Masters Thesis)	(2020)
Lingheng Meng (Ph.D. Thesis)	(2020)
Hemant Surale (Ph.D. Thesis)	(2020)
Bahreh Sarrafzadeh (Ph.D. Thesis)	(2020)
Henry Chen (Masters Thesis)	(2020)
Johann David Wentzel (Masters Thesis)	(2020)
Nicole Dillen (Masters Thesis)	(2019)
Gustavo Fortes Tondello (Ph.D. Thesis)	(2019)
Murat Dikmen (Ph.D. Comprehensive)	(2019)
Alex Bildaru (Masters Thesis)	(2019)
Jeff Avery (Ph.D. Thesis)	(2018)
Caroline Lamb (Ph.D. Thesis)	(2018)
Yetian Wang (Ph.D. Comprehensive)	(2018)
Gustavo Fortes Tondello (Ph.D. Comprehensive)	(2018)
Diane Watson (Ph.D. Comprehensive)	(2017)
Yunjia Sun (Masters Thesis)	(2016)
Quifan Li (Masters Thesis)	(2016)
Matthew Chan (Masters Thesis)	(2016)
Shengyin Pan (Masters Thesis)	(2015)
Brent Komer (Masters Thesis)	(2015)
Carolyn Lamb (Ph.D. Comprehensive)	(2015)
Mingyu Liu (Masters Thesis)	(2015)
Marta Kryven (Ph.D. Comprehensive)	(2015)

### EXTERNAL THESIS EXAMINATION COMMITTEE

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Francisco Maria Calisto (Ph.D. Thesis, IST U. Lisbon)	ongoing
Carter Cousineau (Ph.D. Thesis, University of Guelph)	ongoing
Alexander Butyaev (Ph.D. Thesis, McGill University)	(2019)

### MAJOR PROFESSIONAL SERVICE

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#### Conference Leadership:

<b>HCOMP:</b> AAAI Conference on Human Computation and Crowdsourcing General and Program co-Chair	(2019)
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### OTHER PROFESSIONAL SERVICE

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#### Conference Organizing Committees:

<b>CSCW:</b> ACM Conference on Computer-Supported Cooperative Work and Social Computing	(2019)
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Panels co-Chair  
**CHI:** ACM Conference on Human Factors in Computing Systems (2019)  
 Accessibility co-Chair  
**WebConf:** The Web Conference (formerly WWW) (2019)  
 Track co-Chair, Crowdsourcing and Human Computation Track  
**HCOMP:** AAAI Conference on Human Computation and Crowdsourcing (2016)  
 Doctoral Symposium co-Chair

**Workshop Organizing Committees:**

**CHI:** Designing for Curiosity: An Interdisciplinary Workshop (2017)  
**CSCW:** Science of Citizen Science: Theories, Methodologies and Platforms (2017)  
**HCOMP:** Citizen + X: Crowdsourcing in Science, Public Health and Government (2014)  
**NIPS:** Human Computation for Science and Computational Sustainability (2012)  
**AAAI:** Human Computation Workshop (HCOMP) (2011-2012)  
**KDD:** Human Computation Workshop (HCOMP) (2009-2010)

**Conference Program Committees as Associate Chair or Senior Program Committee Member:**

**AAAI:** Conference on Artificial Intelligence (2019)  
**CHI:** ACM Conference on Human Factors in Computing Systems (2019, 2020)  
**IDC:** ACM Interaction Design and Children Conference (2019)  
**CSCW:** ACM Conference on Computer-Supported Cooperative Work and Social Computing (2015, 2018)  
**CHI Play:** ACM SIGCHI Annual Symposium on Computer-Human Interaction in Play (2015)

**Conference Program Committees as PC member:**

**C&C:** ACM Creativity and Cognition Conference (2019)  
**CI:** Collective Intelligence (2018)  
**GI:** Graphics Interface Conference (2018)  
**UMAP:** ACM Conference on User Modeling, Adaptation and Personalization (2018)  
**SIGIR:** ACM Conference on Research and Development in Information Retrieval (2018)  
**WWW:** International World Wide Web Conference (2014, 2017, 2018)  
**IJCAI:** International Joint Conference on Artificial Intelligence (2016)  
**HCOMP:** AAAI Conference on Human Computation and Crowdsourcing (2013, 2014)  
**AAAI:** Conference on Artificial Intelligence (2012, 2013)  
**ICWSM:** International AAAI Conference on Web and Social Media (2010)

**Reviewer of Conference Publications:**

**CogSci:** Annual Meeting of the Cognitive Science Society (2019)  
**HRI:** ACM/IEEE International Conference on Human-Robot Interaction (2019)  
**IDC:** ACM Interaction Design and Children Conference (2018)  
**CHI:** ACM Conference on Human Factors in Computing Systems (2009-present)  
**UIST:** ACM Symposium on User Interface Software and Technology (2011, 2013-2016, 2018)  
**IUI:** ACM International Conference on Intelligent User Interfaces (2011)  
**NIPS:** Conference on Neural Information Processing Systems (2011, 2012)  
**ICRA:** IEEE International Conference on Robotics and Automation (2012)  
**CSCW:** ACM Conference on Computer Supported Cooperative Work (2016, 2018)

**Workshop Program Committees:**

**IEEE PerCom:** Annotation of User Data for Ubiquitous Systems (2017)  
**KDD:** Interactive Data Exploration and Analytics Workshop (2016)  
**EC:** Crowdsourcing and Online Behavioral Experiments (2014)  
**ECIR:** Gamification for Information Retrieval (2014)  
**KDD:** Crowdsourcing and Data Mining (2012)  
**AAAI:** Wisdom of the Crowd (2012)  
**NIPS:** Computational Social Science and the Wisdom of the Crowds (2010-2011)

**SIGIR:** Crowdsourcing for Information Retrieval (2011)

**Reviewer of Journal Publications:**

Journal of Experimental Psychology (2020)  
Transactions on Learning Technologies (2018)  
ACM Transactions on Interactive Intelligent Systems (TiiS) (2017)  
ACM Transactions on Computer-Human Interaction (ToCHI) (2014)  
Transaction on Pattern Analysis and Machine Intelligence (2014)  
ACM Transactions on Intelligent Systems and Technology (TIST) (2012)  
Journal of Information Retrieval: Special Issue on Crowdsourcing (2011)  
EURASIP Journal on Audio, Speech and Music Processing (2011)  
Citizen Science: Theories and Practice (2016)

**Reviewer of Book Proposals:**

Cambridge University Press (2017)

**Grant Review Panels**

NSF (2015, 2016)  
NSERC-CIHR Collaborative Health Research (CHRP) Project (2015, 2019)

**Journal Editorial Boards:**

**PACMHCI:** Proceedings of ACM-HCI (as Information Director) (2017—present)  
**Citizen Science:** Citizen Science: Theory and Practice (as Board Member) (2015 – 2017)

**Advisory Boards:**

**HCOMP Steering Committee (as Chair in 2020-2021)** (2013 –present)  
**Linguistic Data Consortium:** NSF Computing Research Infrastructure project titled “Novel Incentives and Workflows in Linguistic Data Collection and Annotation” (2017 – present)  
**Cornell:** NSF project titled “Crowd ID: Collaborative Tools Connecting People to Biodiversity through Social Networks and Machine Learning” (2010 – 2014)  
**Penn State University:** NSF IGERT project titled “Big Data Social Science” (2013 – 2014)

**DEPARTMENTAL SERVICE**

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**Graduate/Admission Committee** (2019-2020)

**University of Waterloo Interdisciplinary Task Force** (2019-2020)

**Member, Graduate Recruiting Committee:** (2014-2019)

**Chair, Graduate Recruiting Committee:** (2020-present)

I proposed and helped create a new graduate recruiting event called Undergraduate Research Opportunities Conference (UROC), where we invite top undergraduate students from across Canada to come to University of Waterloo for a 3-day program, to learn about graduate school and our research in computer science. As a direct result of this new conference, many UROC attendees ended up applying to graduate school at University of Waterloo as well as other universities in Canada and abroad. The conference was an annual event from 2015-2018.

**OUTREACH**

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Women in CS (WICS) Workshop on Career in Computing (2021)