

Redesigning Actuarial Science Curriculum: Integrating Data Science & Practice Courses to Better Meet Professional Demands

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Major Modifications to Act-Sci programs

The need for the program redesign came from a few sources:

- (1) the change in the insurance industry and the actuarial profession towards a more data-driven approach;
- (2) the change in insurance market towards a more diverse landscape (long term and short term insurance);
- (3) the change in professional curriculum set by credentialing organizations such as SOA and CAS.

Consultations and Process

- Summer 2017
 - Review existing curriculum and courses, review SOA and CAS new professional syllabi, create preliminary mapping between UofT and professional curricula
 - Consultation with (1) industry advisory board members and other employers; (2) UofT Faculty of Arts and Science Dean's office and Registrar's office; (3) statistics program, economics department, computer science department, business school; (4) actuarial faculty members as well as industry instructors; (5) actuarial students
- Summer and Fall 2017 – Major Modification Proposal
- Fall 2017 and Winter 2018 – UofT academic program governance process (admissions committee, science curriculum committee, Governance Council, etc).
- New program requirements approved in March 2018 and in effect from March 2019.

What does the new curriculum achieve?

- Includes crucial courses in data science and machine learning;
- Allows students to develop their own “concentration” or pathways to complete the program – Life & annuity/long term insurance, P&C/short-term insurance, finance/investment, pension, etc.;
- Creates space for both theoretical courses and practice-oriented courses in students’ completion pathways;
- Provides flexibility/room for future curriculum/course changes due to a new mandatory + elective structure.

New Specialist Program Requirements

- Program completion requirements (13 FCE = 26 semester-long courses):

First Year:

1. First-year advanced calculus (MAT137Y/MAT157Y)
2. Linear Algebra (MAT223H/MAT240H)
3. Micro and Macro Economics (ECO101H1, ECO102H1)

To be completed before the end of Second Year:

1. Intro to Data Science and Statistical Reasoning (STA130H)
2. First-year computer science (CSC108H1/CSC120H1/CSC121H1/CSC148H1)

Second Year:

1. Financial Mathematics I + Financial Derivatives + Intro to Life Contingencies (ACT240H1 and ACT245H1 and ACT247H1)
2. Multivariable Calculus (MAT237Y1/MAT257Y1)
3. Mathematical Statistics (STA257H1, STA261H1)
4. Accounting (MGT201)

New Specialist Program Requirements (continued)

- Higher Years:

1. A set of mandatory courses (3.5 FCEs): intermediate theory courses in major actuarial fields:

Life Contingencies (ACT348H1)

Financial mathematics (ACT370H1)

Loss Models (ACT451H1, ACT452H1)

Regression models (STA302H1)

Data science and machine learning (STA314H1)

Stochastic process (ACT350H1)

New Specialist Program Requirements (continued)

- Higher Years:

2. 2 FCE to be selected from lists 1 (advanced theory) and 2 (practice-oriented courses), allowing different program completion “pathways”:

List 1: Corporate finance (ACT349H1), Reserving methodologies in P&C (ACT371H1), Advanced life contingencies (ACT455H1), Credibility and simulation (ACT466H1), advanced financial mathematics (ACT460H1), Time series model (STA457H1), Statistical Methods for Machine Learning II (STA414H1)

List 2: “Practicum” courses in P&C (ACT372H1, ACT471), Pension (ACT470H1), life & annuity with AXIS software (ACT475H1), and actuarial case studies and communication (ACT473H1).

New Major Program Requirements

- Program completion requirements (8.5 FCE = 17 semester-long courses):

First Year:

1. MAT137Y1 (63%)/MAT157Y1 (60%)
2. MAT223H1/MAT240H1 (should be taken in first year, enforced as a prereq for MAT237Y1)

To be completed before the end of Second Year:

1. **NEW** - STA130H1
2. **NEW**- CSC108H1/CSC120H1/CSC121H1/CSC148H1

New Major Program Requirements (continued)

- Higher Years:

1. ACT240H1, ACT245H1, ACT247H1, ACT348H1, ACT370H1

2. MAT237Y1/MAT257Y1

3. STA257H1, STA261H1

4. ACT451H1, ACT452H1, STA302H1

- STA314H1 (a new course on data science/intro machine learning) is strongly recommended.

Professional Exams with SOA and UofT Course Mapping

UofT course mapping:

- VEE:

- 1) Economics: ECO101+102

- 2) Accounting and Finance: ACT349, MGT201/RSM219

- 3) Mathematical Statistics: STA261

Professional Exams with SOA and UofT Course Mapping (continued)

- Exam Probability (P): STA257
- Exam Financial Mathematics (FM): ACT240, ACT245
- Exam Investment and Financial Markets (IFM): ACT245, ACT370, ACT349
- Exam Long-term actuarial mathematics (LTAM): ACT247, ACT348, ACT455, ACT452, ACT350 (NEW)
- Exam Short-term actuarial mathematics (STAM): ACT451, ACT452, ACT466, ACT371, ACT372, ACT350 (NEW)
- Exam Statistics for Risk Modeling (SRM): STA261, STA302, STA314 (NEW), STA457

Data Science and Machine Learning Courses

- A three-course series: STA130, STA314, STA414
- STA130: intro to data science:
 - Learn from data using statistical methods (supervised and unsupervised learning), including methods for description, explanation and prediction,
 - Strengths and limitations of those methods
 - Statistical analyses in R
 - Communicate results of a data analysis to both technical and non-technical audience, including using data visualization
- Active learning: Final project to conduct a statistical analysis of data regarding perceived disparity of internet use around the world. The data is from CIA's The World Factbook. Students present their findings in the style of a poster display of a professional scientific conference.

Data Science and Machine Learning Courses

- STA314: Statistical Methods for Machine Learning I:
 - training error, test error and cross-validation;
 - classification, regression, and logistic regression;
 - principal component analysis;
 - stochastic gradient descent;
 - decision trees and random forests;
 - k-means clustering and nearest neighbour methods.
- Active learning: weekly computational tutorials, frequent student assignments in R studio to apply the methods to real-world data

Data Science and Machine Learning Courses

- STA414: Statistical Methods for Machine Learning II:
 - Supervised vs unsupervised learning (• Least squares • Overfitting and generalization • Effect of regularization • Cross validation)
 - Probabilistic Models (• Maximum likelihood estimation • Some useful distributions • Exponential families • Regression and classification • Basis function models)
 - Optimization and Decision Theory (• Bias-variance tradeoff • Generalization • Statistical decision theory • Gradient descent • Stochastic gradient descent)
 - Unsupervised learning (• Clustering • Mixture models • EM algorithm • Principal component analysis)
 - Latent variables (• Graphical Model notation • Markov models • Hidden Markov models • Exact inference)
 - Fitting large models (• Automatic differentiation • Vectorization • Neural Networks)
 - Approximate inference (• MCMC • Variational Inference • Bayesian neural networks)
 - Reinforcement learning (discrete random variables)
 - Variational autoencoders (• Nonlinear dimensionality reduction • Recognition networks)
 - Generative Models (• Generative adversarial networks • Normalizing flows)

UofT Practice-oriented Courses

The following courses taught by FSAs, FCIAAs or FCASs from the industry can help students gain practical knowledge from various practice tracks and potentially improve competitiveness when applying for internship and employment:

- Property and Casualty (P&C): ACT371, ACT372, ACT471
- Life and annuity (and AXIS software): ACT475
- Pension: ACT470
- Professional Communication (using case studies in various practice tracks): ACT473

Upcoming in 2020-2021 academic year

Professional Experience (PE) Program for actuarial science SPECIALIST!

Proposed Program Structure:

- (1) The program will be structured as an “integrated learning requirement” which is mandatory for students enrolled in the program. This way international students can also get the work visa to do internships.
- (2) The PE mandatory requirement is comprised of a PE course (0.5FCE) and a practicum component (0.5FCE). The PE course should be taken in the fall semester of the 3rd year, although 4th year specialist students can enroll too.
- (3) The practicum component: a semester-long internship (longer is fine)

Upcoming in 2020-2021 academic year

Support for our Specialist students under the Professional Experience (PE) Program includes:

- 1) Invited speakers series (from every major field of actuarial science)
- 2) Professional skill workshops (business writing, career planning, networking skills, resume workshop, interview skills)
- 3) Networking events to connect students with professionals
- 4) Final report and presentation event with industry partners