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Distinguished Academic Actuaries: An Interview With John Beekman

Page 5

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CHAIRPERSON'S CORNER

A Time of Transition

By Breanne Richins

As I end my term as chair of the Education & Research (E&R) Section, I would like to thank all those who have served both as council members and friends of the council, as well as those at the Society of Actuaries (SOA). I have enjoyed getting to know those I've served with and can see their dedication to the actuarial profession and education.

The 54th Actuarial Research Conference (ARC), hosted at Indiana University–Purdue University Indianapolis (IUPUI), was truly a great example of collaboration, as several universities came together to organize and execute an excellent conference. A special thank-you to Jeff Beckley and his team for their hard work and hospitality in planning and supporting the conference. You are invited to read the conference highlights in Jeff's recap article.

I look forward to the 2020 ARC, which will be held at the University of Nebraska–Lincoln on August 9–12. With its strong actuarial science program and connections to industry, I'm sure there will be interesting sessions and opportunities to learn something new.

The E&R council is also engaged in other actuarial conferences, including the SOA Annual Meeting & Exhibit, Life and Annuity Symposium, and Health Meeting. With all these opportunities, I encourage you to become involved and volunteer either as a council member or friend of the council.

Tom Wakefield will be taking over as chairperson of the E&R Section Council in November. He is a great choice to lead and will work to further promote the council's goal to support and encourage actuarial education and research.

Thank you for the chance to serve as chairperson. See you all in Nebraska! ■

Breanne Richins, FSA, is an education specialist at the University of Minnesota. She can be reached at *richi018@umn.edu*.

AT THE LECTERN

Letter From the Editor

By Colin M. Ramsay

I am pleased to present to you the December 2019 issue of *Expanding Horizons*. One particularly pleasant event that occurred during the preparation of this issue was my meeting with professor John Beekman at the 54th Actuarial Research Conference (ARC) held in Indianapolis in August. Professor Beekman is being featured in the current issue as our distinguished academic actuary. I first met him in 1984 when he served as the external examiner for my doctoral thesis while I was a student at the University of Waterloo, Canada. We had not seen each other since then, so I was very happy to meet and have lunch with him and his dear wife, Jane. After lunch I interviewed John (and to some extent Jane, as she often filled in some details and contexts during our discussion). As this was my first formal interview of anyone, I used an audio recorder as well as my cell phone just in case one of them failed.

Once again, we are fortunate to have another thought-provoking submission to the "The Art of Actuarial Practice" series. The contributor this time is Guy Thomas, with his provocative article "From Actuarial Education and Research to Practice."

Jeff Beckley provides us with his observations on the 54th ARC. Sue Vagts and Shengchao Zhuang invite us to attend the 55th ARC to be hosted by the University of Nebraska–Lincoln (UNL) from Sunday, August 9, through Wednesday, August 12, 2020, at the College of Business on the UNL downtown campus.

There are also several fine articles related to actuarial education that were presented at the 2019 Actuarial Teaching Conference held June 27–28, 2019, in Columbus, OH.

As you peruse this issue, I encourage you to send us your feedback on specific articles in this or other recently published issues. You are also invited to send us articles on any aspect of actuarial education and/or research. Although *Expanding Horizons* is not a peer-reviewed scholarly publication, all articles are screened for relevance to the section's membership. ■

Colin M. Ramsay, ASA, MAAA, is a professor at the University of Nebraska–Lincoln. He can be reached at *cramsay@unl.edu*.

DISTINGUISHED ACADEMIC ACTUARIES

An Interview With John Beekman

John Beekman, Ph.D., ASA, MAAA

This interview was conducted on Thursday, Aug. 15, 2019, while I was attending the Actuarial Research Conference at Indiana University—Purdue University Indianapolis (IUPUI) in Indianapolis. I first met Professor John Beekman, Ph.D., ASA, MAAA, in 1984 when he served as the external examiner for my doctoral thesis while I was a student at the University of Waterloo, Canada. It was my first meeting with Professor Beekman since then, so it was indeed a great pleasure to meet with him for this interview. We were joined by his wife, Jane.

Q: Tell us about your background. How did you enter the actuarial profession?

A: I heard about actuarial science in high school. So I made up my mind in undergraduate college to try to become an actuary. I started college in 1949 and earned a bachelor's degree in 1953. I was in the Army from 1953 to 1955. Then I came back for my master's degree, which I achieved by 1957. I worked for State Farm Life one summer, and then I worked for a consulting actuarial firm in Minneapolis. Following that I took a job with Minnesota Mutual Life Insurance Company in St. Paul, Minnesota. I spent two years with Minnesota Mutual, and then in 1961, I started a Ph.D. program in mathematics at the University of Minnesota in Minneapolis–St. Paul. I also worked for a consulting firm called George V. Stennis Consulting Actuaries. I am not sure if that company is still around. If they are, they've probably changed their name because a lot of the consulting companies have merged.

Q: Did you work in the insurance industry before entering academia? If so, what prompted you to move into academia?

A: As I mentioned earlier, I did work in the insurance industry before entering academia. I was an actuary at Minnesota Mutual. But when I was in the Army, I taught algebra in the evenings, and I decided I loved teaching. Because of that, I decided to get a master's degree in math, so I went to the University of Iowa. I also took math education as an elective while at the University of Iowa. Later I transferred to the University of Minnesota, where I earned a Ph.D. in mathematics. Because I so liked teaching while I was in Iowa City and Minneapolis, I decided to change careers and become an academic.

Q: What challenges did you encounter upon entering the actuarial profession?

A: The actuarial exams. The first one I passed was an English comprehension exam. Fortunately, we were given about one or two hours per day to study for actuarial exams. Then, with time, I passed the mathematics-related actuarial exams to become an associate. I did not take the exams that would have led me to become an FSA because by that time I had a regular job, and I didn't want to give up that job.

> Teaching and doing research in actuarial science is a fulfilling career that combines well with raising a family.

Q: Who motivated you to go into academia and/or research?

A: At the University of Minnesota, I wrote my Ph.D. thesis on function space integrals, and I had a wonderful advisor, Robert Cameron. He had worked for the secretive Manhattan Project in the middle of World War II, which developed the atom bomb. He was very inspirational. Although he sort of knew about actuarial science, that of course was not the main thing he was doing.

Q: Who was an influential person in your professional life, and why?

A: There were several people. In my early career I can start with Gerald Toy, FSA, who hired me for summer work in his actuarial consulting firm. I did that for four summers. I can say the main person was Robert Hogg, who was a professor of statistics at the University of Iowa. I had him for one class in my junior year and a one-year class as a senior. After I came back from the Army, I had him for two years in a master's program. There was also my doctoral advisor at the University of Minnesota, Robert Cameron. Later on there was Cecil Nesbitt at the University of Michigan; he was very inspirational. In addition, there was Jim Hickman of the University of Wisconsin. With respect to Cecil Nesbitt, during a summer conference, he was telling us that George Andrews was working on a book about the Social Security program and needed help. Cecil asked if there was anybody in this conference who could help. I said, "Oh, yeah, I'll help." So I volunteered and that's how I got started with George. We co-authored this book about Social Security entitled *Actuarial Projections for the Old-Age, Survivors, and Disability Insurance Program of Social Security in the United States of America*.[1]

Q: What is your personal philosophy with regard to teaching and/or research?

A: Teaching provides opportunities for working with young students. Research gives one the challenges of new ideas.

Q: Thinking back on your career, what are your biggest accomplishments? Any disappointments? Any memories or moments that stand out above the rest?

A: Probably establishing an actuarial science program at Ball State University. We graduated hundreds of people with bachelor's and master's degrees in actuarial science. We started the master's degree first, then the bachelor's degree.

Next would be writing those books. I wrote the first book, *Two Stochastic Processes*, by myself.[2] The second book, which we have already talked about, was on Social Security with George Andrews. A third book arose in a similar fashion. I was at a math conference in Madison, Wisconsin, and Cecil Nesbitt said that Nathan Keyfitz, who was working on a book on demography, needed help. Nathan was a professor at Harvard at that time. So I thought, "Oh, good grief, do I have any business working with him?" But it worked out pretty well, and so I worked with him on a textbook called *Demography Through Problems*.[3] In addition, I published more than 50 research papers. My co-authors were Newton Bowers of Drake University, Nathan Keyfitz of Harvard University, and George Andrews of Oberlin College. I must add that in the last five years, I have co-authored five papers with David Ober, a retired professor of physics, and that has been a great pleasure.

Another big accomplishment for Jane and I was with our two daughters, Karen and Ann. Karen was born in 1961, and she's now a professor at Oregon Health and Science University in Portland, Oregon. She is married and has two children, except they're not children anymore. Our second daughter, Ann, works in Cincinnati with young adults between 18 and 22 years of age who are disabled in some way. For example, some may have Asperger's syndrome. They enter Ann's program in order to get a high school diploma so they can be employed. Ann works with them for a year, helping them to put together their resumes, prepare for interviews, and find employment. Another thing that Jane and I do is volunteer to help with our local Christian Food Pantry to provide food for the needy.

I do not recall any disappointments.

Q: What might someone be surprised to know about you?

A: Well, Jane and I are both in the church choir at a Lutheran church in Muncie, Indiana. We sing on Sundays nine months a year. We don't sing in the summer because I think the director wants a vacation. I'm sure it'll be very big surprise for the readers to know that we are not solo material. I also like to play golf with another person, Ramon Avalon, and we walk nine holes once a week. Jane and I also like to go on "Road Scholars" trips. We've been on 18 of them and plan to go on the 19th one soon. It will be held in Philadelphia. Also, I have been asked to give speeches on actuarial science to students in Muncie. I don't know how many students I got from those speeches, but their math teacher decided to join the actuarial science program at Ball State University. I recruited the teacher, but I didn't do that intentionally.

Q: How do you see the future of actuarial science in your country?

A: Well, I think it's very strong in the United States. I think actuarial science is very, very useful to millions of people who need solid pensions and annuities, solid health insurance and solid life insurance, and they need actuaries to make those things happen on a solid mathematical basis.

Q: What would you advise someone considering entering the actuarial profession?

A: Well, I guess I would say, number one, do you like mathematics? You have to like it, and you have to be willing to study very hard. If that's true for you, then a good career using mathematics is actuarial science. You have options: you can work in a consulting manner, you can work for a company, or you can be an academic. If I could rewind my life, I would do this all over again and become an actuarial science professor.

Q: As you know, actuarial education has become mainstream and is taught in many universities worldwide. As you reflect on your career, are there any closing comments (or advice) that you may want to pass on to current (especially younger) actuarial science faculty at large?

A: Teaching and doing research in actuarial science is a fulfilling career that combines well with raising a family. If you're teaching mathematics anyway, and you want to serve people using your mathematical training, you might at least consider teaching actuarial science because it's a very useful profession. ■

ENDNOTES

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THE ART OF ACTUARIAL SCIENCE

From Actuarial Education and Research to Practice: Long and Variable Lags

By Guy Thomas

The brief from the editor of *Expanding Horizons* for this essay was to give some personal reflections on how actuarial education and research influence actuarial practice. "Education and research" is an example of a conjugate metonym: two words linked together so as to imply that each is inseparable from the other (like "true and fair" or "rest and recuperation" or "drink and drugs"). I prefer to deny the metonym and consider each term separately, using the construct of mutual influence. That is, actuarial research both *influences* and *is influenced by* actuarial practice. The same is true for actuarial education. But it is true for each in different ways, and with long and variable lags.

ACTUARIAL RESEARCH

Actuarial research is influenced by practice insofar as research typically starts from a problem or observation from practice. I say "typically" because this pattern is not universal: some "blue sky" research starts from an idea that no practitioner has ever considered. But in an applied discipline, a practical problem is the typical starting point. It does not follow that either the questions posed or their answers must be immediately accessible and attractive to practitioners. This is for two reasons. First, answers that are already accessible do not require research! Second, most research is to some degree a critique of current practice, either because it casts new light on what practitioners are doing or because it suggests better ways of doing it.

Actuarial research influences practice with long and variable time lags, which reflect contingencies such as the proximity of the researcher to practitioners with sufficient mathematical inclinations, as well as language, location and style of publication. A few examples will illustrate this. In 1903 the Swedish actuary Filip Lundberg set out all the essentials of collective risk theory,[1] but because he wrote in Swedish, the ideas were not really recognized until Harald Cramér presented them in English in 1930.[2] Even then, they were largely ignored by British actuaries for another 50 years. Redington's 1952 breakthrough concept of immunization was published in a British journal and hence quickly assimilated by British actuaries,[3] but it was largely ignored by financial economists and bond market practitioners for another 30 years. Sklar invented the copula in 1959,[4] but perhaps because he had no direct connections to the actuarial world, it was another 40 years before Li proposed an application in risk management.[5]

These examples suggest that even the most important new ideas are often initially discounted by practitioners and require repeated presentation over time in a variety of formats and venues before they influence practice. This has also been my experience with my own concept of "loss coverage." I make no claim that this idea is comparable to the contributions of the aforementioned authors. But because this is a personal essay, I shall use its history to illustrate the origination and development of new ideas.

> Contrary to orthodox wisdom, some adverse selection can make insurance work better for the population as a whole.

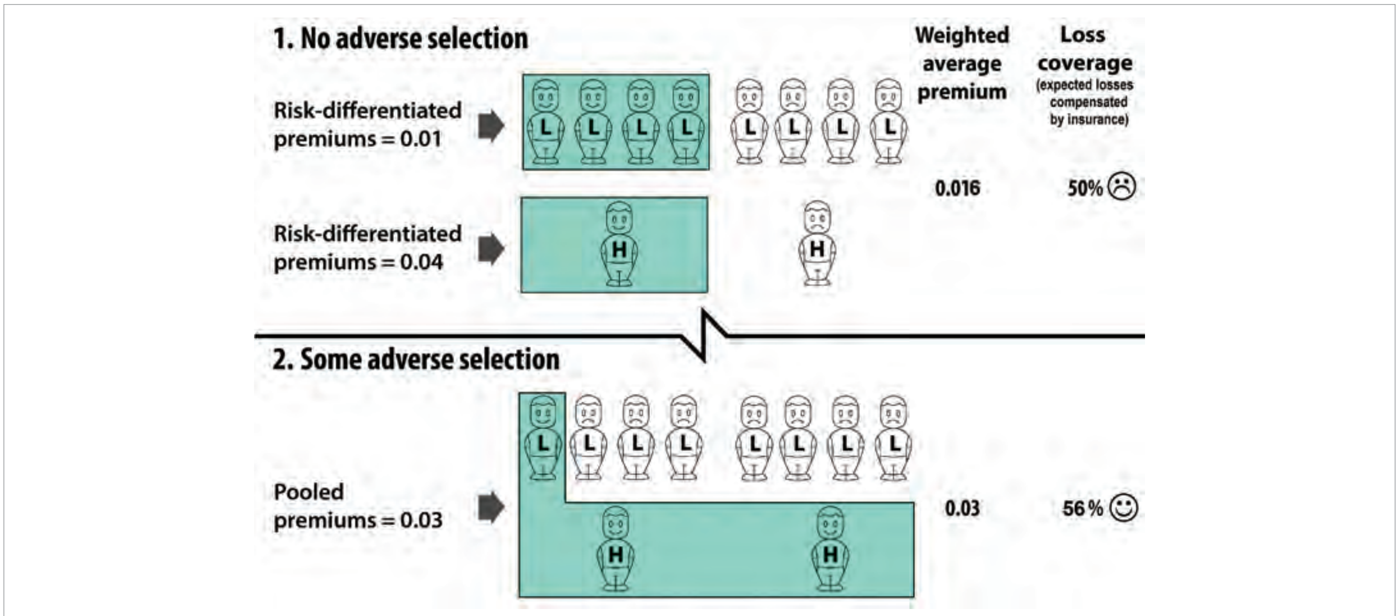
LOSS COVERAGE

Regulatory restrictions on risk classification (e.g., genetics, gender) are increasingly common in personal insurance markets. Although such restrictions can help to meet social objectives, they can also lead to adverse selection. This is usually seen as a problem, both for insurers and for society. The concept of loss coverage represents a partial counterargument: it suggests that contrary to orthodox wisdom, some adverse selection can make insurance work better for the population as a whole.

The concept of loss coverage can be illustrated by a toy example. To provide context, it helps to think of life insurance, where we typically observe a majority of "standard" lives and a small number of much higher risk lives (say with a genetic predisposition to illness).

Consider a population of just 10 lives with two alternative scenarios for risk classification. First, risk-differentiated prices are charged, and a subset of the population buys insurance. Second, risk classification is banned, leading to adverse selection: a different (smaller) subset of the population buys insurance. Assume that all losses and insurance cover are for unit amounts (this simplifies the presentation, but it is not necessary).

Figure 1
Alternative Scenarios for Risk Classification of a Sample Population



Source: Guy Thomas, *Loss Coverage: Why Insurance Works Better with Some Adverse Selection* (Cambridge, UK: Cambridge University Press, 2017). Reprinted with permission.

The two scenarios are shown in the upper and lower parts of Figure 1. "H" indicates high-risk participants (probability of loss 0.04), and "L" indicates low-risk participants (probability of loss 0.01). In each scenario, the shaded area over some of the participants denote the risks covered by insurance.

In Scenario 1, risk-differentiated premiums are charged. Higher and lower risk groups each face a price equivalent to their probability of loss (an actuarially fair price). The demand response of each risk group to an actuarially fair price is the same: exactly half the members of each group buy insurance. The shading shows that a total of five risks are covered.

The weighted average of the premiums paid in scenario 1 is (4 × 0.01 +1 × 0.04)/5 = 0.016. Since higher and lower risks are insured in the same proportions as they exist in the population, there is no adverse selection. The expected losses compensated by insurance for the whole population, which I call the "loss coverage," can be indexed by

$$\frac{(4 \times 0.01 + 1 \times 0.04)}{(8 \times 0.01 + 2 \times 0.04)} = 50\%.$$

In scenario 2, risk classification is banned, so insurers have to charge a common "pooled" premium to both higher and lower risks. Higher risks buy more insurance, and lower risks buy less (adverse selection). The shading shows that three risks (compared with five previously) are now covered. The pooled premium is set as the weighted average of the true risks, so that expected profits on low risks exactly offset expected losses on high risks. This weighted average premium is (1 × 0.01 +2 × 0.04)/3 = 0.03.

Note that the weighted average premium is higher in scenario 2, and the number of risks insured is lower. These are the essential features of adverse selection, which scenario 2 accurately and completely represents. But there is a surprise: despite the adverse selection in this scenario, the expected losses compensated by insurance for the whole population are now higher. The loss coverage in Scenario 2 is

$$\frac{(1 \times 0.01 + 2 \times 0.04)}{(8 \times 0.01 + 2 \times 0.04)} = 56\%.$$

I argue that scenario 2, with a higher expected fraction of the population's losses compensated by insurance, is superior from a social viewpoint to scenario 1. This superiority arises, not despite adverse selection, but because of adverse selection. So on the criterion of loss coverage, some adverse selection can be a good thing.

Where did this counterintuitive idea come from? Not from thinking about adverse selection in the abstract. Rather it came from thinking about a practical problem: the impetus in many countries in the late 1990s to ban insurers from asking about certain presymptomatic genetic tests. Actuaries and economists argued against such bans because they would induce adverse selection, and initially I agreed; it seemed obvious that if adverse selection caused the market to disappear, this would not be helpful to anyone. But on more careful reflection, it occurred to me that if adverse selection was only moderate, this meant that *the people who need insurance more are more likely to buy it* (and the people who need it less are less likely to buy it). Looking at it this way, it was not obvious why a public policymaker should regard adverse selection as a disadvantage at all.

I articulated a primitive version of this idea in a few sentences in an article in 2001. At that time, the idea was undeveloped, and I did not fully understand its potential myself. Sometime later, I realized that the point could be made more clearly by toy examples where a quantity I called "loss coverage" increased under adverse selection, similar to Figure 1.[6] I then developed a more formal model.[7] At this point I had a nice theory and some affirmation through publication. But I could not see any way to develop it further until my colleague Pradip Tapadar, who has better mathematical skills than mine, took an interest in the idea. His contribution led to a refreshed research program that produced a doctoral thesis,[8] several more papers[9] and a book.[10]

The slow pace of development partly reflects the fact that I spend most of my time on investment, not actuarial research. But I think it also illustrates the general point that many new ideas take time to be fully understood, even by their originators, and also require presentation in multiple formats and venues to gain acceptance. The various formats are not just repetition, but (we hope) an upward trajectory, with successive presentations homing in on the core of an idea, as well as clarifying its weaknesses and limitations, and adapting it for maximum utility to different audiences.

So actuarial research both influences and is influenced by actuarial practice, but on different time scales. Actuarial research is influenced by practice insofar as it typically (albeit not invariably) starts from a problem in current practice. Actuarial research influences practice when research results are adopted by practitioners, though with long and variable time lags as illustrated in the examples given here.

ACTUARIAL EDUCATION

Much actuarial education, especially that provided by professional bodies rather than universities, is strongly influenced by practice. It is hard to see how it could be otherwise, given that professional associations are primarily concerned with certifying fitness for practice rather than with abstract ideals of intellectual exploration. We all become what we learn; so if you want to become an actuary, you need to learn what actuaries do.

But education heavily influenced by practice has two major drawbacks. First, the need for consensus about what is to be taught and the inevitable delays in updating syllabi mean that

the main influence is actually not *current* practice but *lagged* practice. Consequently, obsolescent topics tend to be given unjustified weight. The tables of commutation functions with which I became proficient in the late 1980s spring to mind; the same is probably true of the spreadsheet skills emphasized today. Second, education that is influenced by a lagged version of practice cannot cover developments that are not yet salient to practitioners. This can lead to emerging issues that are "close but different" to current practitioner interests being ceded to other professions.

An instructive example of the latter phenomenon from another profession is the loss of control by medical doctors of bioethics education in the United States.[11] Starting in the 1960s, new medical technologies such as heart transplants pointed to a need for ethical analysis of medical decision making. Senior doctors and medical societies were reluctant to engage with this development, which they saw as an unwarranted interference with the tradition of experience-based ethical judgments by individual clinicians (cf. "actuarial judgment"). To fill the gap, other researchers such as theologians and philosophers began to analyze medical decision making and call themselves bioethicists. By the early 1980s, when political and public pressure led to demands for ethics to be taught to medical students, there existed a substantial body of published work on medical decision making by bioethicists but very little by doctors. So medical ethics came to be taught using paradigms and textbooks developed by bioethicists rather than physicians. Many doctors were annoyed by these developments, feeling that it was absurd for non-doctors to preside over a field whose very title proclaimed that it was "medical"; they also felt that bioethicists tended to be too cautious about new technologies. But the doctors had only themselves to blame; their earlier disdain for the formal study of ethics had created the void that nondoctor bioethicists had filled.

In actuarial science, a close but different field that practitioners currently seem to disdain is risk management from the perspectives of individuals. Actuarial risk management focuses predominantly on the management of financial institutions. In the past quarter-century these institutions, often advised by actuaries, have pursued better risk management mainly through the expedient of offloading their risks onto individuals. Insurance guarantees and defined benefit pensions have been progressively withdrawn. Risk has been shifted toward individuals, but the locus of actuarial thought and effort has not. In the short term, it is probably more lucrative for actuaries to charge consultancy fees to institutions shedding risks than to individuals newly lumbered with risks. But in the long term, this focus on institutions (and an educational syllabus influenced by it) may lead to a similar outcome as for doctors and bioethics: if actuaries disdain to adopt the perspective of individuals, new types of advisers will develop the field. If advice to institutions remains lucrative, perhaps actuaries will not care; but will it still be lucrative when the last defined benefit pension fund has closed?

The shortcomings of education influenced by lagged practice can be mitigated by including in the curriculum some material inspired by research rather than practice. This type of research-led education is (or should be) an advantage for universities compared to other suppliers of actuarial education; the conjugate metonym of education and research makes more sense in a university context than anywhere else. At the University of Kent, we now teach the idea of loss coverage in postgraduate courses, even though it is antithetical to current practitioner views. Our hope is that this type of research-inspired education will (with a long time lag) be an exception to the prevalent pattern for actuarial education: it will influence practice rather than reflect a lagged version of it.

> The distinctive worldview of economists probably enhances their academic prestige, but it also fosters a striking obtuseness to ideologically dissonant facts.

INVESTMENT

The editor's brief also asked me to reflect on how actuarial education has influenced me as an investor. My initial reaction was along the lines of "not much": most of what I do as an investor seems closer to a blend of investigative journalism and epistemological introspection than to actuarial science. But on more careful reflection, I realized that the investment curriculum I followed early in my career probably did influence my development as an investor—or at least gave me implicit permission to try.

When I studied for the investment examinations in the United Kingdom in the late 1980s, a sizable minority of U.K. actuaries had been involved for some decades in active portfolio management. On the usual lagged-practice principle, the examination curriculum emphasized the comparative analysis of individual securities. The implicit message was that active portfolio management was a worthwhile endeavor, which probably encouraged me to make my own efforts in this direction. But after I qualified, in the early 1990s, actuarial involvement in active management in the United Kingdom declined. Again following the lagged-practice principle, the curriculum was changed in the late 1990s: material on comparative security analysis was removed and more emphasis given to the idea of efficient markets. The implicit message was that active portfolio management was not worthwhile and that one would be foolish to try. Whatever the truth of the matter, we all have limited time and attention; to teach one thing is to exclude another. I am glad that I was taught that active investment is worth trying.

These changes, arguably contradictions, in the curriculum from one decade to the next reflect the truth that actuarial science is not a discipline with a distinctive core of unchanging principles. Instead, it seems to consist of "whatever mathematics is currently useful for managing long-term financial institutions," a toolkit of tenuously related techniques thrown together by accidents of history, like the communist country of Yugoslavia. This irreverent comparison sounds like a criticism, but it need not be. Many academic disciplines, especially the social sciences most proximate to actuarial science, seem more committed to methodology than to truth. The distinctive worldview of economists probably enhances their academic prestige, but it also fosters a striking obtuseness to ideologically dissonant facts. In the end, the lack of rigid ideology and methodology in the actuarial toolkit may be a strength rather than a weakness, at least as far as understanding the world and solving practical problems are concerned. ■

Guy Thomas is an actuary and investor, and an honorary lecturer at the University of Kent. He can be reached at *r.g.thomas@kent.ac.uk*.

ENDNOTES

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10 Guy Thomas, *Loss Coverage: Why Insurance Works Better with Some Adverse Selection* (Cambridge, UK: Cambridge University Press, 2017).

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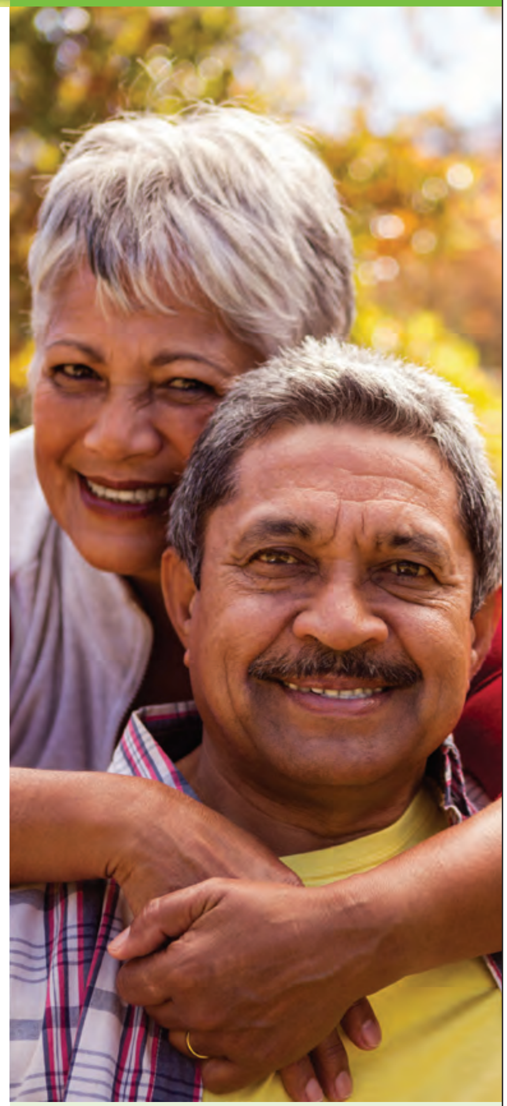

ACTUARIAL RESEARCH CONFERENCE

A Retrospective of the 2019 Actuarial Research Conference

By Jeff Beckley

The 2019 Actuarial Research Conference (ARC) was held in Indianapolis in the middle of August. Hosted by Purdue University, Indiana University—Purdue University Indianapolis, Ball State University, Butler University, University of Notre Dame and DePauw University, the conference was blessed with mild weather, great keynote speakers and 220 attendees.

The ARC started on Wednesday evening with a reception at the Skyline Club, which is on the top floor of the OneAmerica Tower. The attendees enjoyed a spectacular panoramic view of the Indianapolis skyline.

Conference sessions began on Thursday morning with a keynote presentation by Andrew Cairns. Andrew is professor of financial mathematics at Heriot-Watt University, Edinburgh, and director of the Actuarial Research Centre of the Institute and Faculty of Actuaries. Andrew gave a fascinating talk about U.S. mortality and underlying trends by socioeconomic group and cause of death. His eminently understandable talk is available at *https://www.youtube.com/watch?v=M7D7i2oMK80&feature=youtu.be*.

On Friday, the second keynote speaker was Jan Vecer. Jan is professor at the Charles University in Prague where he teaches courses in mathematical finance and stochastic analysis. He gave a very interesting talk on long-term portfolio protection, including two novel approaches to protect against potential portfolio losses on a long-term horizon for actively traded portfolios. His talk is available at *https://www.youtube.com/watch?v=RBRJznkO3i4&feature=youtu.be*.

The conference banquet was Friday night at the Dallara Indycar Factory, which manufactures the chassis for Indycar racers. The factory has a large banquet area with interactive exhibits. Attendees were able to compete for the fastest lap around the Indianapolis 500 track using simulators. The pole position was won by Steve Guo. Way to go, Steve!

The final keynote address on Saturday morning was by Anya Prince, an associate professor at the University of Iowa College of Law. Her teaching and research interests explore the ethical, legal and social implications of genomic testing, with particular focus on genetic discrimination and privacy rights, the intersection of clinical and research ethics, and insurance coverage of genetic technologies and interventions. Her talk, "Should Life Insurers Use an Applicant's Genetic Information?: Policy Lessons from the UK, Australia, and Canada," was very timely and interesting. It is available at *https://www.youtube.com/watch?v=-s7iJbbidq0&feature=youtu.be*.

Besides the keynote presentations, there were five invited sessions:

- Professionalism
- Update on Actuarial Education
- Actuarial Society Sponsored Research
- Industry-Academic Cooperation
- Catastrophe Modeling and Insurance

This year's ARC had many other excellent presentations, approximately 100 of which were given by academic faculty and graduate students. The quality of all the presentations I attended was very high and impressive.

Of course, the networking opportunities to catch up and learn from friends, colleagues and new acquaintances are often as valuable as the more formal sessions.

The ARC in 2020 will be held at the University of Nebraska–Lincoln. I look forward to seeing you there. ■

Jeff Beckley, FSA, MAAA, is director of the actuarial science program at Purdue University and was the 2019 chair of the ARC organizing committee. He can be reached at *jbeckley@purdue.edu*.

ACTUARIAL RESEARCH CONFERENCE

University of Nebraska–Lincoln Invites You to ARC 2020

By Sue Vagts and Shengchao Zhuang

The University of Nebraska-Lincoln (UNL) is proud to be the host for the 55th Actuarial Research Conference (ARC). The conference will take place from Sunday, August 9, through Wednesday, August 12, 2020, at the College of Business on the UNL city campus in downtown Lincoln.

Air travel to Lincoln is convenient. The campus is only a 10-minute drive from the Lincoln Airport (LNK), from which you may take hotel shuttles, Uber, taxis or rental cars to your hotel. Additionally, Lincoln is a one-hour cab ride away from the Eppley Airfield Omaha Airport (OMA), where plentiful direct flights from all major U.S. cities arrive every day. Attendees may choose to stay on campus in suite-style housing or off campus in one of three hotels, all of which are within walking distance of the campus.

Lincoln is a medium-sized city with many theaters, museums, parks and sport facilities, as well as a variety of excellent restaurants and bars. Notable museums include the International Quilt Museum, Sheldon Art Gallery, Morrill Hall and a Children's Museum all on or very near campus. Off campus, the Lincoln Children's Zoo and Sunken Gardens are just a short distance away.

ACTIVITIES AT ARC 2020

The conference will kick off with an evening reception on Sunday in the atrium of the College of Business. This will be followed by three days of engaging and informative sessions, including a poster session by graduate and undergraduate students. For conference attendees, we have planned a visit to the Omaha Henry Doorly Zoo and Aquarium, as it is consistently ranked one of the world's best zoos. The zoo offers a variety of travel-worthy experiences, including wandering through the world's largest indoor desert, the largest indoor rainforest in North America, the Scott Aquarium, the Kingdoms of the Night exhibit and many more adventures. Our half-day at the zoo will be followed by a banquet dinner next to the manta rays inside the Scott Aquarium.

ABOUT THE UNL ACTUARIAL SCIENCE PROGRAM

The University of Nebraska-Lincoln boasts a strong history in actuarial science. In the 1920s, math professor Floyd Harper taught actuarial mathematics. The program formalized in 1957 when industry leaders in the Nebraska Actuaries Club hired a director and provided external funding and oversight. Today, our students can major in actuarial science either through the College of Business or the College of Arts and Sciences. We are physically housed in the College of Business, and in 2017 we moved into our new 240,000-square-foot Howard L. Hawks Hall, which will be the venue for the conference. Within the College of Business, we are a part of the Department of Finance and currently have seven full-time faculty members in actuarial science and one in risk management and insurance. Of these eight faculty members, six are active in research, and two are professors of practice with industry experience. We offer both an undergraduate and a graduate program in actuarial science. Our 400 students come from 23 states and 14 countries.

The website for the conference, which will be updated often, is *https://business.unl.edu/arc*. It includes videos about the conference and the city.

The Nebraska faculty, staff, students and industry all look forward to welcoming you at the 2020 ARC for a great conference and a fantastic visit to Lincoln! ■

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ACTUARIAL TEACHING CONFERENCE

Using Pedagogy to Improve Learning and Instruction

By Russell Jay Hendel

This article presents concrete methods facilitating retention and understanding, as well as satisfaction with—and efficiency of—the learning experience. At first blush, it appears relevant to instructors for both preliminary and fellowship exams. But it is also relevant to candidates who engage in self-study. Finally, it is relevant to professional actuaries learning new material as they drive through their career path.

PEDAGOGY THEORY—EXECUTIVE FUNCTION

Most candidates are familiar with the Marzano pedagogical hierarchy,[1] according to which all subject matter is classified into one of four levels: (1) knowledge retrieval, (2) comprehension, (3) analysis and (4) knowledge utilization. Each successive level is more challenging than those that precede it. Each level is in turn explained by sublevels; for example, material is classified in the analysis level if it involves classification, generalization, specification, error correction or matching.

Recently, after reviewing the hierarchies of Bloom, Marzano, Gagne, Van Hiele, Anderson and others, I found a very simple unification of these theories that is much easier to use and implement: a pedagogic activity is higher level if it involves two or more distinct parts of the mind.[2] Psychologists use the term *executive function* (EF) to refer to that part of the mind that is used when two or more other mind components are simultaneously active.

The following examples illustrate the variety of applications of EF to learning.

Example 1: The Rule of Four

Deborah Hughes-Hallet initiated a calculus reform movement based on the rule of four.[3] This rule says that every calculus problem, concept and illustration should involve four distinct brain activities: verbal, algebraic-formal, geometric-visual and computational. For example, it is not enough to teach the first derivative test to locate extrema, one must also teach how to recognize extrema in both a graph and computational table, as well as learn the verbal cues requiring extrema for their solution. Here, superior pedagogy is achieved through the use of four distinct brain areas requiring EF.

Example 2: Multicomponent Problems

My syllabus always declares that all problems will be multicomponent; there will be no plug-in or drill problems. For example, instead of the drill problem, How much does $1,000 accumulate to in 3 years at an annual effective rate of 3%? I instead may use the following:

> $1,000 is deposited in an account earning 3% for 3 years; the accumulated value is deposited in another account earning 4% for 4 years. Calculate the actuarial equivalent level effective rate that would allow $1,000 upon deposit to accumulate in 7 years to the same amount accumulated in the 4% account.

Here, superior pedagogy is achieved through a multicomponent problem requiring separate brain areas, or EF, for the two (or more) subproblems to be solved.[4]

Example 3: The Trail Making Test

Figure 1 (see page 17) contains miniature versions of the Part A and Part B tests of the trail making test (the actual test uses 25 items versus the six shown in the figure).[5] An examiner presents a blank test to an examinee. The test has two parts, as shown. The examiner then provides a pencil and instructs the examinee to connect the numbers and letters available so as to create a sequential trail. Figure 2 shows a completed trail making test.

Figure 1
A Blank Trail Making Test Given to an Examinee Who Must Create Trails

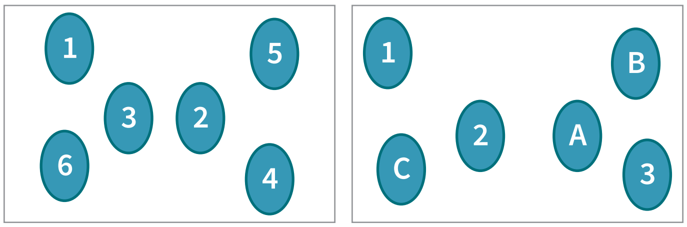
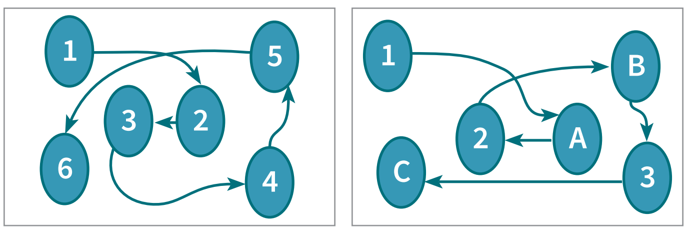


Figure 2
The Completed Trail Making Test



In administering the test, the examiner first asks the examinee to create a trail for the Part A test and times (e.g., in seconds) how long this takes. This process is repeated for the Part B test. The examiner assesses the examinee by subtracting the time needed to complete Part A from the time needed to complete Part B.

Although all people can easily complete the two tests (i.e., create the trails), the Part B test uses two parts of the brain (the part for letters and the part for numbers) while the Part A test only uses one. Hence, the Part B test always takes longer than the Part A test. Psychologists and neurologists use this simple-appearing test to diagnose brain injury (e.g., after a stroke or car accident) and to assess the chances of recovery. I often use this test to show that simple improvements, such as adding another brain area (letters and numbers), can actually have significant impact although they may appear inconsequential.

We continue the illustrative examples with material from the preliminary actuarial exams.[6] The next two examples demonstrate how continually approaching all subject matter with multiple brain areas, such as the rule of four, facilitates discovery of the most elegant approach. In the next three examples, we replace traditional algebraic proofs with punchy, crisp, instant proofs that do not require tedious manipulations.

Example 4: Achieving Simplicity Using a Geometric Approach

Table 1 presents a purely geometric argument proving both the formula for an n-year annuity immediate certain and the geometric series sum formula. The interpretation of Table 1 should be clear. An investor deposits \$1 at time $t = 0$ in a bank account earning at effective rate i and withdraws that \$1 at time $t = n$. The present value (PV) of the investor's transactions are $1 - v^n$. The bank, seeing the \$1 in the account, deposits an amount \$$i$ of interest at the end of every period. We can calculate the PV of the bank's transactions in two ways: (1) It is the sum of the discounted values of each interest deposit; and (2) since it is a sequence of end-of-period payments of i, definitionally, it is an annuity of amount i. A no-arbitrage argument requires the investor's and bank's PV to be equal, instantly leading to a non-algebraic proof of the formula for the annuity immediate and sum of geometric series.

Table 1
Activity of an Investor and a Bank in an Account Earning Effective Rate i

Time t =	0	1	2	…	n	Present Value
Investor	1				–1	$1 - v^n$
Bank		i	i		i	$i(v + v^2 + \ldots + v^n) = ia_{\overline{n}\rvert i}$

Example 5: Live Application of the Theory in This Article

Many of the principles of this article (e.g., the rule of four, the idea of addressing multiple modalities when teaching) are known. One goal of this article is to encourage readers to take these familiar ideas and apply them to current textbooks, handouts and monographs to achieve improvements in pedagogical approach.

As an exercise, the reader is invited to apply the same proof method presented in Table 1 to the Society of Actuaries (SOA) study note regarding interest rate swaps,[7] with a goal of obtaining an elegant simple proof that the fixed payment of an m-year deferred n-year swap is given by $(P_m - P_{m+n})/(P_{m+1} + P_{m+2} + \ldots + P_{m+n})$, where P_k is the price of a 0-coupon bond with maturity 1 at time k.

Example 6: Achieving Simplicity Using a Calculator Approach

In the following example, the use of a calculator approach—versus an algebraic approach—provides an elegant, punchy and simple solution to a traditional loan-refinancing problem.

> A borrower takes out a 15-year loan for \$400,000, with level end-of-month payments, at an annual nominal interest rate of 9% convertible monthly. Immediately after the 36th payment, the borrower decides to refinance the loan at an annual nominal interest rate of j, convertible monthly. The remaining term of the loan is

Table 2
Solution to the Loan Problem Using the BA II Plus TV Line

N	I	PV	PMT	FV	Comment
15*12	9/12	–4	CPT	0	Original loan
12*12	Keep	CPT	Keep	Keep	OLB_{36}
Keep	CPT	Keep	Last row – 0.0040988	Keep	Refinanced loan

Note: All numbers in the problem were divided by 100,000. OLB = outstanding loan balance.

> kept at twelve years, and level payments continue to be made at the end of the month. However, each payment is now $409.88 lower than each payment from the original loan. Calculate *j*.[8]

The traditional approach to solving this problem would be to write down equations and then calculate (perhaps manually). By using the BA II Plus Time Value (TV) line, an elegant solution is accomplished with only 10 keystrokes, as shown in Table 2.

The interpretation of Table 2 should be clear. PV, N, I, PV, and FV represent the price, number of periods, effective annual rate, periodic payment and any extra one-time terminal payment, respectively. The first row of Table 2 corresponds to the more familiar $4 = Ra_{\overline{180}|0.75\%}$. A feeling of greater familiarity with equations versus the TV table reflects a teaching style emphasizing algebraic over other modalities of solution. The TV table is well suited for a quick solution of all loan problems.

PEDAGOGY THEORY—GOAL SETTING

In my review and unification of the educational hierarchies, EF is one of four pillars of pedagogy, two of which deal with subject matter content. The EF pillar corresponding to the rule of four has already been discussed. The other pillar dealing with subject-matter content is goal setting (GS) referring to the best method to subdivide complex problems into a sequence of subgoals. Good GS requires three attributes. Subgoals should be (1) clear and specific, (2) achievable in a reasonable amount of time, and (3) challenging. The literature speaks about the GS paradox: although increasing challenge seems to delay achievable timely, studies show that such increases actually increase learning and performance.[9]

Readers who have taken or taught preliminary exams will recognize the following examples as difficult for candidates. These problems are difficult precisely because candidates do not know where to begin or what to do. We can succinctly formulate this difficulty as follows: while candidates have been taught subject matter, they have not been taught GS methods for these types of problems. In the examples that follow, we will only describe the high-level GS steps. Indeed, presenting formulas would not be challenging and hence not meet GS criteria. It is precisely by giving specific but high-level subgoals that learning increases.

Example 7: Multi-Rate and Payment Problems

A standard way to make a problem with a "plug-in" solution challenging is to replace parameters with pairs of parameters (operating at different times). For example, in interest and mortality theory a single interest rate can be replaced by two interest rates (operating at different times); a single payment can be replaced by two payments (operating at different times). Candidates who memorize formulae can initially be bewildered by such a problem, not knowing how to begin a solution.

> Calculate the present value of a loan paid back by four end-of-year payments of 10 following by three end-of-year payments of 15. Assume the annual effective interest rates are 1.5% for the first two years, 1% for the next three years and 2% for the last two years.

Such multi-interest, multi-payment problems are common in several preliminary exams. When I give such problems for homework, I will simply give a high-level tip of *how* to create subgoals: "Break the problem into subproblems, each of which has one: (1) interest rate, (2) cash flow (scheme), and (3) money growth method." This tip immediately suggests breaking up the problem into computing the PV of four loans: (1) a two-year loan of 10 at effective rate 1.5%, (2) a two-year loan of 10 at 1%, (3) a one-year loan of 15 at 1%, and (4) a two-year loan of 15 at 2%.The PV of the problem loan is then the sum of the discounted values of these four loans.

Example 8: Reinvestment Problems

Reinvestment problems naturally have several components, each with different parameters. The candidate can typically solve any particular component but fails to solve the entire problem precisely because of a lack of organizational tools to properly set subgoals.

Table 3
A Complete Set of Four Methods for Calculating BV and OLB

Method Name	Description	When Used
Prospective	PV future payments	If you know *n* and *i*
Retrospective	CV loan – AV payments	If you know *P* and *i*
BV_1–BV_2	Buy at BV_1, receive coupons and sell at BV_2	If you don't know *n* or *P*
Spreadsheet method	$I_t = i * OLB_{t-1}$, $R = I + P$, $OLB_{t-1} - P_t = OLB_t$	Line by line

> An amount P is paid by an investor for a 10-year, \$10 coupon bond, with 1,000 redemption value yielding 4.5%. As each coupon is received, half is deposited into an account earning 5%, while the remainder is pocketed as profits. Calculate the overall yield to the investor over the 10 years.

Here is the GS for this problem: (1) Create a separate problem for each distinct interest rate; (2) identify each cash flow in the problem as an inflow, outflow or intermediate flow (e.g., the \$5 half-coupons initially deposited in the 5% account are intermediate cashflows since it is the accumulated value of this account at time $t = 10$, which is the inflow to the investor); and (3) create a summary timeline with all inflow and outflow cash flows. The solution of the equation of value for this summary timeline provides the solution for the reinvestment problem. This tip applies to all reinvestment problems which, as noted earlier, are typically difficult because students lack proper GS tools.

Example 9: A Fellowship Approach (Pros and Cons of Multiple Methods)

Certain topics in the preliminary examination syllabi are challenging because multiple methods exist. Doing many examples with each method does not by itself achieve pedagogical mastery. Rather, a proper approach is to use the GS methods of fellowship-exams: What are the possible methods? What are the pros and cons? Which method is best in this problem? Such a fellowship-examination approach is challenging, an important prerequisite for proper GS.

> A five-year bond with quarterly coupon payments of 2.5 has book values (BV) of 970.95 and 980.44 at times $t = 2$ and $t = 3$, respectively. Calculate i, P, C, and r.

As indicated, solving this problem by formulas, although clear and timely achievable, would not be challenging and hence would not meet GS criteria. In solving this problem, I use a fellowship-exam approach: (1) Determine the methods of calculating outstanding balance, (2) identify the pros and cons of each method, (3) decide which method is appropriate to this problem, and (4) calculate the values. Answers to parts 1 and 2 are presented in Table 3.

The prospective and retrospective methods are not useful in this problem because neither n, P, nor i are known. Therefore, we must use the BV_1–BV_2 approach. The following equations can be used to solve for i and P: $970.95 = 2.5a_{\overline{4}|i} + 980.44v_i^4$; $P = 2.5a_{\overline{8}|i} + 970.95v_i^8$. Similar equations can then be used to solve for C and r. The use of a fellowship-exam approach (which always emphasizes proper GS) is useful in several otherwise difficult problem domains.

A pedagogic activity is higher level if it involves two or more distinct parts of the mind.

USING EF AND GS TOGETHER

EF and GS can and should be combined. We can illustrate this with the topic of distributions in the Probability exam syllabus. EF suggests summarizing this information in a rectangular database array format. Each row in the database would contain one distribution. The first three sets of columns, which frequently do occur in this database form in textbooks, contain: (A) distribution name and parameters; (B) associated functions (f, F, P and s); and (C) statistics (moments, central moments, percentiles, moments with caps and deductibles). Notice that, for example, (B) is a *set* of four columns. We would add four more sets of columns: (D) sums of random variables (RV); (E) relationships between distributions; (F) generating functions (PGF, MGF and products); (G) computational implications (e.g., values for E[X] indicate evaluation of integrals that may have independent value in certain problems). The database is a *visual* aid for dealing with formal algebraic relationships. The next example illustrates this approach.

Example 10: Database Approach to Distributions

> An actuary determines that the claim size for a certain class of accidents is a random variable, X, with moment-generating function $M_X(t) = (1 - 2{,}500t)^{-4}$ Calculate the standard deviation of the claim size for this class of accidents.[10]

We show here how to use the visual aid of the database to establish GS steps:

1. Determine column sets relevant to the problem solution. *Solution*: The problem gives an MGF corresponding to category (F) of columns.

2. Look through the (F) columns to find a functional form similar to $1/(1 - 2{,}500t)^4$. *Solution*: Without the exponent of 4, the function $1/(1 - 2{,}500t)$ resembles the exponential distribution MGF. (Note: We assume the database is incomplete; otherwise, we could directly look up the gamma distribution MGF.)

3. To deal with the exponent of 4, look through the individual columns in the (F) category of generating functions. *Solution*: If the database is set up properly, one column would give the product formula for the MGF of sums of random variables.

4. Go back to the exponential row and look up either the category (D) columns (sums of random variables) or the category (E) columns (relationships between distributions) to deal with the sum. *Solution*: A sum of four identically distributed and independent exponential random variables is gamma distributed. We also obtain related parameters.

5. Go to the row with the gamma distribution to the category (C) columns. *Result*: Calculate the variance, and hence the standard deviation, of the gamma distribution to answer the question.

We again emphasize that the visual aid, as well as the GS steps of tracing a path in rows and columns, is a high-level description that still requires candidate work (so it is challenging) but is clear and achievable timely. Hence, this tip fulfills GS criteria and helps students.

CONCLUSION

This article has shown how to use EF and GS with specific illustrative examples. Challenging problems should always address multiple brain areas. Good GS should establish clear subgoals, each one achievable timely, yet challenging the candidate with more work than just plugging in. GS can be assisted by using alternate brain areas. We believe these techniques, when properly applied, can enrich the learning and instruction experience and performance. We encourage readers to apply these principles to the material they learn and teach. ■

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ENDNOTES

1 Robert J. Marzano, *Designing a New Taxonomy of Educational Objectives* (Thousand Oaks, CA: Corwin Press, 2000).

2 Russell J. Hendel, "Leadership for Improving Student Success through Higher Cognitive Instruction," in *Comprehensive Problem-Solving and Skill Development for Next-Generation Leaders*, ed. Ronald A. Styron Jr. and Jennifer Styron (Hershey, PA: IGI Global, 2017), 230–54.

3 The rule of four was originally the rule of three. See, for example, Oliver Knill, "On the Harvard Consortium Calculus," last updated February 14, 2009, *http://www.math.harvard.edu/~knill/pedagogy/harvardcalculus/*.

4 Russell J. Hendel, "Dr. Hendel's FM Lecture Notes," 2017 and 2019, *http://www.rashiyomi.com/math/DrHendelsFMLectureNotes.pdf*.

5 "Trail Making Test (TMT) Parts A & B," *http://apps.usd.edu/coglab/schieber/psyc423/pdf/IowaTrailMaking.pdf*.

6 Throughout this presentation I assume the reader is familiar with (1) the material on the Probability and Financial Mathematics preliminary SOA examinations and (2) the BA II plus Texas Instrument (TI) calculator. The SOA website (*www.soa.org*) has both syllabi and standard textbooks. The TI website presents the BA II plus guidebook (*https://education.ti.com/en/guidebook/details/en/ADF11FB65B284B6195B0A7E9502784BA/baiiplus*).

7 Jeffrey Beckley, "Interest Rate Swaps," Education and Examination Committee of the Society of Actuaries Financial Mathematics Study Note, 2017, *https://www.soa.org/globalassets/assets/Files/Edu/2016/edu-2016-fm-25-17-interest-rate-swaps.pdf*.

8 Society of Actuaries, "Exam FM Sample Questions," Problem #75, *https://www.soa.org/globalassets/assets/Files/Edu/2017/exam-fm-sample-questions.pdf*.

9 Supra note 2.

10 Society of Actuaries, "Exam P Sample Questions," Problem #57, *https://www.soa.org/globalassets/assets/Files/Edu/edu-exam-p-sample-quest.pdf*.

ACTUARIAL TEACHING CONFERENCE

Launching a New Actuarial Science Program

By Vajira Manathunga and Jennifer Yantz

The Department of Mathematics and Statistics at Austin Peay State University (APSU) launched its actuarial science program in the fall semester of 2017. Developing a new such program at a small state university presented a series of challenges. In this article we would like to share our experiences while developing the new program, challenges we faced, and the successes we have realized within this short period of time. Our aim is to share our experience with educators at other small schools who are considering implementing a new actuarial science program. Maybe your school has never had actuarial science courses, or perhaps you want to extend your curriculum beyond a few courses that cover select exams to offering a minor or major. In either case, by sharing our experiences, we hope you will avoid the same pitfalls we faced and develop your new programs efficiently and effectively.

When implementing an actuarial science program, there are many elements to be considered. In the sections that follow, we will discuss considerations related to the program's administration and curriculum. We will also discuss considerations of how to ensure the program meets students' needs.

ADMINISTRATION

When developing a new program, it is important to think about the following:

- Determine the mission and vision of the program
- Identify the department to house the program
- Create an advisory board
- Determine the type of program to be offered
- Establish short- and long-term program goals

Determine the Mission and Vision

The first question about the program to be answered is, why is it needed? Does this new program align with the university's overall mission and vision statement? For example, APSU's mission statement specifically states

> Developing programs and services that address regional needs, and providing collaborative opportunities that connect university expertise with private and public resources. Collectively, these endeavors contribute significantly to the intellectual, economic, social, physical, and cultural development of the region …

In our state, Tennessee, there is only one institution with an actuarial science program that covers more than two preliminary actuarial exams and only three universities (including APSU) that cover at least one actuarial exam.[1] Nashville, the capital of Tennessee, is a regional hub for actuarial firms. Thus, an actuarial science program was a regional need that came under the APSU mission statement.

Identify the Department to House the Program

Once development of a new program is justified, you must determine which department will host it. Actuarial science programs are generally hosted in either a department of mathematics and statistics or a department of business and finance. Students taking actuarial science in a department of business or finance will take a larger variety of business and finance courses. However, these students must still take the full calculus sequence and one or two probability and statistics courses to obtain the knowledge needed to sit for the preliminary exams—perhaps earning a minor in mathematics. Students taking actuarial science in a mathematics or statistics department will develop a strong mathematical background and will take business and finance courses as a minor or as electives—obtaining VEE credit to demonstrate their knowledge of business operations. Either department will serve students well on their pathway to membership in the Society of Actuaries (SOA). At APSU, our recently developed graduate programs in predictive analytics and mathematical finance are managed jointly by the Mathematics and Statistics Department and the Computer Science and Information Technology Department. We strategically chose to house the undergraduate actuarial science program in the department of mathematics and statistics.

Create an Advisory Board

An advisory board will guide you as you make important decisions related to the implementation of the program. It should include professionals with industry experience in a variety of fields in which actuaries work, such as life and health insurance, property and casualty insurance, and pensions and retirement funds. It is possible that some of your alumni have pursued additional education or employment in the field of actuarial science after leaving your institution. If so, these individuals would also make excellent board members. An educator from a noncompeting college or university with an established actuarial science program would also bring valuable experience to the table.

A challenge we faced in forming an advisory board was our lack of contacts with professionals in the actuarial science industry. We are working to establish those connections, but the SOA and the Casualty Actuarial Society (CAS) have programs that can help. Both organizations will connect you with a liaison who is a professional actuary.[2] At APSU, we also use an existing board for our financial mathematics program with two additional actuarial science professionals.

Determine the Type of Program to Be Offered

Once the department housing the program is identified and an advisory board is in place, the next step is to decide what type of program will be offered. You can offer either a major, a concentration or a minor in actuarial science. This decision needs to be made in conjunction with choices regarding the amount of exam coverage to be offered and how many courses will be developed. You should also consider the accreditation requirements at your school when deciding the type of program to be offered. To meet accreditation requirements at our university, a program major must graduate a certain number of students each year. Since our program is new, we don't expect to reach that level for a few years. So we first decided that a concentration would best fit our needs. However, as interest in the program increased, we realized that students in majors other than mathematics could be served by offering a minor in actuarial science. Starting in fall 2019, APSU began offering either a concentration or a minor in this subject.[3]

Establish Short- and Long-Term Goals

After the type of program to be offered is established, you next need to identify the short- and long-term goals for the program. Educators need to understand that current job trends require students to pass at least one or two exams held by the SOA or CAS to be considered for internships or employment. Students will be looking for a college or university with a comprehensive program. Thus, being designated as an SOA Center of Actuarial Excellence (CAE) school[4] or winning a CAS University Award[5] may be considered long-term goals. Both designations will identify your institution as one with a program of excellence and will serve as a recruitment tool for potential candidates.

APSU applied for and obtained UCAP-IC (Universities and Colleges with Actuarial Science Programs—Introductory Curriculum) status, which is the first step on the pathway to the CAE designation. The UCAP review process can take a few months, so plan on completing this goal as soon as possible. We are currently in the process of applying for UCAP-AC (Advanced Curriculum) status. The criteria for both designations require evidence of coverage of specific exam topics, so your course syllabi must be in good order before applying for these designations. Additionally, the Validation by Education Experience (VEE) courses must be offered before you can apply for UCAP status (one course for IC and all three for AC), so plan to obtain VEE approval before applying for either designation. (VEE approval is discussed more in the next section.)

CURRICULUM

While there are many important decisions to be made regarding the curriculum that your institution will offer, the following are three main decisions you must make immediately:

- Determine which courses to offer
- Establish VEE Credit
- Identify program faculty

Determine Which Courses to Offer

The type of program you will offer—major, concentration or minor—will constrain your choices regarding the number of courses or credit hours offered in actuarial science. You should examine your existing courses to determine if any may serve in the actuarial science program. For either existing or new courses, you will have to decide what content to cover. The SOA and CAS provide syllabi for each exam, and you can design courses that cover exactly those requirements, or you might choose to add some general subject knowledge to your courses. Keep in mind that the topics covered and texts listed on your syllabi will be scrutinized for compliance if you apply for UCAP-IC or UCAP-AC designations. It might benefit your students if you create a one-credit-hour course for exam preparation. A challenge related to curriculum is that you must continue to monitor changes made to the SOA and CAS syllabi or exam structure and adjust your course descriptions and syllabi accordingly to retain UCAP designations if they have been granted. At APSU, the course creation process took about one year to complete, so allow yourself adequate time for new courses or changes to be approved.

For example, when we first created a financial derivative (IFM) class, we were targeting the now-retired Models for Financial Economics (MFE) exam. This exam didn't contain topics such as the capital asset pricing model. Our course bulletin says, "This course covers introductory financial derivatives, general properties of options, the binomial option pricing model, the Black-Scholes option pricing model, Greeks, risk management, and interest rate derivatives. This course prepares students for actuarial exam 3F/MFE." With the new IFM syllabus, we now need to change the wording in the course bulletin, but that won't be possible at our school without changing the course number. That means we need to create a new course. The best way to avoid this situation is by not adding the exam name to the course description in the bulletin.

Establish Validation by Educational Experience Credit

Both the SOA and the CAS have a syllabus of essential basic education of which candidates must show evidence when applying for membership in the societies. These experiences are called Validation by Educational Experience and include education related to accounting, economics, finance and mathematical statistics. While VEE credit is applied for by individuals, a high-quality college or university program should provide these experiences to students so they will later be eligible for admission to the societies without needing further education. You should carefully choose courses for your major, concentration or minor that address the specific topics required.[6] If your program is housed in the Department of Mathematics or Statistics, then you will need the cooperation of faculty in other departments that offer these courses to ensure that the corresponding syllabi show that the appropriate topics are covered. Once approved, your college or university will be listed in the VEE directory. Students looking for an actuarial science program know that a program with approved VEE courses will provide them with the education needed to successfully apply for admission to the societies once they pass the relevant exams. APSU has received approval for all of the VEE courses. This is another area that is subject to change, and administrators of an actuarial science program must continually monitor the requirements to remain in compliance.

Identify Program Faculty

Naturally you will need faculty to teach the actuarial science courses. You should first examine existing faculty to determine if they can meet the needs of the program. Once qualified faculty are identified, your department must consider the ways in which they will be involved in the design of curriculum for courses in the program. Furthermore, you must decide how you will support faculty who may need to sit for actuarial exams or pursue additional designations. Support could take the form of release time to study for exams or funds to pay for exam preparation materials and covering the cost of exams. The department should also consider adding the attainment of society designations to faculty requirements for retention, tenure and promotion. This move may encourage more faculty to show interest in teaching the actuarial science courses.

If the current faculty do not meet the program needs, you must search for new faculty. You should decide what combination of education and expertise you are looking for in a candidate. Attracting a quality candidate to a small school can be challenging. At APSU, we used existing faculty to cover most courses, and we secured a one-year visiting professor to meet our needs temporarily.

MEETING STUDENTS' NEEDS

The first goal of a program must be to meet the needs of its students. Students with the best chance of securing a job in actuarial science are those who have passed exams, experienced real world-connections to actuarial science and have developed excellent professional skills.

Success on Exams

Most employers expect newly hired actuaries to have passed two or more exams. The pass rate for preliminary exams P and FM in spring 2019 were 47 percent and 49.3 percent, respectively. Your administration must be patient if you initially have very low pass rates. You have created courses that cover the SOA and CAS syllabi, and students are passing those courses, but you may wonder why few students are passing the exams. In our experience, students at small schools are often impeded by financial barriers related to the cost of exam preparation materials and the cost of exams. At APSU, we proposed and received a grant from the Casualty Actuaries of the Southeast.[7] One purpose of the grant was to fund a materials library for students to use when preparing for preliminary exams. The grant will also reimburse a limited number of students who pass preliminary exams. Your program may seek other internal or external sources of funds to help students overcome expenses incurred when preparing and taking exams.

Real-World Connections to Actuarial Science

Employers may be faced with stacks of résumés from qualified candidates. Students who have some real-world experience will stand above the rest. Your program can provide some limited experience by using case studies in the curriculum, but the best source of real-world experience is through an internship. Program administrators should use connections formed between the college or university and industry professionals to establish internship opportunities. Faculty should also guide students toward seeking such opportunities. Students may need faculty support in the creation of résumés and the application process. At APSU, we successfully placed two students in internships at the State of Tennessee Department of Treasury in the 2018–2019 academic year.

Another way to engage students in real-world actuarial science is through research or competitions. The SOA and CAS both have many opportunities that faculty can use to enhance their students' knowledge of real-world actuarial activities. For example, the SOA offers a Student Research Case Study Challenge, which students can complete and submit in competition with other schools for a chance to be awarded grants.[8] Faculty who engage in consulting work may also utilize students in supporting roles and thus increase their students' exposure to practical work experience.

Excellent Professional Skills

In addition to passing exams and gaining real-world experience, students must demonstrate excellent professional skills. The employer panel at the 2019 SOA Actuarial Teaching Conference was an excellent source of information regarding what skills employers are looking for in new hires. Companies expect people to communicate effectively in writing and speaking. Newly hired employees must possess advanced skills in Microsoft Excel and Word, as well as some experience with programming or the use of statistical software packages such as R and SAS. Students can attain this expertise if they are engaged in a carefully planned curriculum where these skills are developed and the presentation of high-quality work is expected. At APSU, we are developing a new course that includes experiences with Excel and requires students to write and communicate solutions to small cases through presentations. The course will also explore the ethics that professional actuaries must exhibit.

Two presentations at the 2019 SOA Actuarial Teaching Conference provided excellent guidance in adding these experiences to your curriculum. Joanna Mitro, University of Cincinnati, described an introduction to actuarial science course that was developed for students to take early in their program of study.[9] Heather S. Clemens and Sue Vagts, University of Nebraska–Lincoln, shared details of their course designed to develop young professionals.[10]

SUMMARY

Launching a new program is a daunting task, and many things must be considered. Decisions based on careful planning and thought will lead to a successful program. This careful planning will also eliminate much of the stress and frustration that can accompany the implementation of a new program. We hope this article will provide some insight into the process and allow you to create your new program effectively and efficiently. Some of the ideas here were developed by us as the process evolved, and some were gained through collaboration with colleagues at the 2017 and 2019 SOA Actuarial Teaching Conferences. We encourage you to join the SOA and CAS online forums and to attend conferences where the sharing of ideas is a valuable resource. We would also be happy to communicate with anyone who has questions or would like more information concerning the implementation of a new program. ■

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ENDNOTES

1 Society of Actuaries, "Universities & Colleges with Actuarial Programs (UCAP)," *https://www.soa.org/Education/Resources/Actuarial-Colleges/actuarial-college-listings-details.aspx*.

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ACTUARIAL TEACHING CONFERENCE

Actuarial Science 2.0: Redesigning the Undergraduate Curriculum at the University of Toronto

By Vicki Zhang

The actuarial profession is marching into the age of big data. Increasingly, employers in various actuarial fields are requiring new hires to have sophisticated knowledge of statistics and data science. To meet the new demands from the industry and the profession, the Society of Actuaries (SOA) has implemented its new curriculum from 2018. One of the key additions to this new curriculum is a new exam in Statistics for Risk Modeling (SRM), which covers modern statistical and data science techniques. There will also be a new proctored project on predictive analytics as a capstone requirement for obtaining associateship with the SOA.

To stay current with new trends and demands from the profession, as well as in line with the new SOA curriculum, the actuarial science programs (both the Specialist and Major programs) at the University of Toronto (UofT) underwent major modifications. We started this process in the summer of 2017. We first reviewed the existing actuarial curriculum and courses and the new SOA professional syllabi and created a preliminary mapping between the two curricula. We then started a lengthy consultation process with various parties. We consulted with our academic partners—Statistics, Mathematics, Economics, Computer Science and the Business School—as our actuarial students will be taking several core courses with those departments and programs. UofT has an industry advisory board comprising senior actuaries in the insurance industry. Several of our practice-oriented courses are also taught by seasoned working professionals. We thus held meetings to hear feedback and opinions from industry experts and potential employers. We also met with students at the actuarial student club to get their take on the curriculum redesign. The dean's office (at the Faculty of Arts and Science) and the registrar's office were also crucial interlocutors in this process to ensure that the proper enrollment processes were followed and their internal systems were up to speed with the new program requirements.

During the Fall 2017 and Winter 2018 semesters, we submitted the program major modification proposals to UofT's academic program governance process (admissions committee, science curriculum committee, governance council, etc.), and in March 2018 the new program was approved. It is important that our students are well prepared for the new requirements, so we provided a one-year grace period to students interested in enrolling in actuarial science programs after spending their first year completing foundational courses. The new program became officially effective from March 2019.

THE NEW CURRICULUM AT A GLANCE

Under the new curriculum, students need to complete 26 semester-long courses to fulfill the actuarial science Specialist program requirements. In their first year, they will complete foundational courses in calculus, linear algebra, and micro- and macroeconomics. They will also complete their first data science course (STA130) and first computer science course focusing on programming in Python.

From the second year of study, students will be introduced to the actuarial science core curriculum (introductory financial mathematics, financial derivatives and life contingencies). They will take a two-course sequence in mathematical statistics and complete the multivariable calculus course, as well as a course in accounting (through the business school).

> Curriculum redesign has been a long journey involving examination of gaps in the curriculum, intensive consultations with academic and industry partners, careful reconstruction of program pathways and an open mind for further evolutions.

In their higher years of study (third and fourth), they will complete a set of seven mandatory courses and at least four electives. The mandatory course list includes intermediate theory courses in major actuarial tracks (life contingencies, financial math, loss models and stochastic process). It also includes a course

on regression models and the second data science and machine learning course (STA314).

The elective courses are further divided into advanced theory and practice-oriented courses. This is where the academic “pathway” comes into play. For example, a student interested in life insurance will take an advanced life contingencies theory course from list 1 and a life and annuity practicum course using AXIS software from list 2. A student interested in property and casualty insurance will take a credibility and simulation course, among others, from list 1 and a three-course property and casualty (P&C) practicum sequence. A student interested in investment and finance may take an advanced financial mathematics course from list 1 and a pension practicum from list 2. List 1 also includes the third data science and machine learning course (STA414) for students particularly interested in data analytics and predictive modeling.

What Does the New Curriculum Achieve?

The new actuarial science Specialist and Major programs reflect a significant structural change from the previous ones, especially for the Specialist program. The new curriculum has the following characteristics:

1. It includes crucial courses in statistical learning and data science (i.e., a three-course sequence).
2. It 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 and so on.
3. It creates space for both theoretical courses and practice-oriented courses in students’ completion pathways.
4. It provides flexibility/room for future curriculum/course changes due to a new mandatory-plus-elective structure.

DATA SCIENCE AND PRACTICE-ORIENTED COURSES

The highlight of the curriculum redesign is the official addition of data science and machine learning courses into the actuarial science core curriculum. Under the new curriculum, as part of the foundational studies in the first year, students are introduced to major supervised and unsupervised learning methods and working on real data in the R studio. They are also required to communicate the results of data analysis to both technical and nontechnical audiences, including using data visualization. In a final project for the first-year data science course, students are asked to conduct a statistical analysis on data they downloaded from the public domain. The analysis requires data wrangling, exploratory plots and summary statistics, statistical tests, and the use of regression models or classification trees to answer a particular research question. In their third year of study, students further hone their data analysis skills in their second data science (and intro to machine learning) course that is modeled after the 2017 book *An Introduction to Statistical Learning with Applications in R*.[1] Students who want to dive even deeper into the field can take a fourth-year course on machine learning, where more mathematical and theoretical work awaits them. This course offers a broad view of model building and optimization using probabilistic building blocks and prepares students for a rigorous graduate program in machine learning.

Another important addition to the new curriculum is a set of practice-oriented courses. UofT has been offering these courses for quite a few years, but with the curriculum redesign, we have formally incorporated them into the Specialist requirements so that students can earn program credits when taking them. The courses are co-designed and taught by fellows of the SOA, Canadian Institute of Actuaries (CIA), or Casualty Actuarial Society (CAS). They are case study and project-based and often include a strong communication component where students regularly present their work to a nontechnical audience. Ethics is also a critical component of most courses. Students gain practical knowledge from various actuarial tracks, including life and annuity, P&C and pension. All practice-oriented courses are small seminars with a cap of around 25 to 30 students to ensure ample interactions between the instructors and students.

UPCOMING INITIATIVE

With the new academic curriculum in place, our next step is to develop a Professional Experience component for the program. This mandatory component will comprise a professional experience course and a practicum element. The course will include an invited speaker series, a professional skill workshop series, industry and alumni networking events, and various assignments and presentations. The practicum component can be fulfilled with either a semester-long internship or an extra fourth-year practice-oriented course with additional project work with an industry professional.

The curriculum redesign has been a long journey involving a close examination of the gaps in the university curriculum, a series of intensive consultations with both academic and industry partners, a careful reconstruction of program pathways and an open mind for further evolutions. Our hope is that with the new sequence of data science and practice-oriented courses, the completion pathways that match students' professional interests and the upcoming professional experience program, our students will be well rounded and better prepared for the new era of insurance practice and research. ■

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ENDNOTE

1 Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani, *An Introduction to Statistical Learning with Applications in R* (New York: Springer, 2017).

ACTUAL TEACHING CONFERENCE

Creative Thinking Through Actuarial Projects

By Stefanos Orfanos

This article—and the short presentation I gave at the 2019 Actuarial Teaching Conference (ATC)—arose from teaching a two-course sequence in loss models last year. I would like to express my gratitude to the ATC committee for the opportunity to present, to colleagues for their interest in what I had to say and to Professor Colin Ramsay for the invitation to contribute to *Expanding Horizons*.

There is a sense of individualism in actuarial science that is quite distinct from other subjects. A common belief is that students can major in any one of many disciplines and end up becoming actuaries, so there is considerable freedom about the choice of curriculum. Even when they major in actuarial science, the understanding is that they will eventually have to study on their own. And finally, the actuarial courses they do take often have a very narrow focus: to help them pass the corresponding exams.

A side effect is a paucity of discussion on the application of pedagogical theories to actuarial science and, in particular, a lack of a creative pedagogy for actuarial science.

> It seems plausible that creativity will be the deciding factor between being valuable and relevant in the workplace or being made redundant.

But what is creative pedagogy? It can be defined as the educational approach that seeks to inspire and grow students' creative faculties by means of suitable learning activities and experiences. And what is creativity? This is perhaps best illustrated by means of well-known examples from math or physics, such as Archimedes' idea to measure the volume of the king's crown by submerging it in water, young Gauss' ingenious summation trick to the question $1 + 2 + \ldots + 100 = ?$, or even the standard way of showing that the Gaussian density actually integrates to 1. Creativity is thus the result of an idiosyncratically deep understanding.

Creativity has been celebrated through the ages. One may argue that is because it is so rare or so difficult to cultivate, but a closer look reveals that is not necessarily the case. In fact, some societies saw a tremendous blossoming of creativity at certain times, while at other times they were stagnant. It is rather the outsized impact that creativity can have on human civilization and progress that is the key. Looking forward to the coming era of automation, it seems plausible that creativity will be the deciding factor between being valuable and relevant in the workplace or being made redundant.

The first goal then is to develop a separate concept of creativity, one that aligns better with the practice of actuarial science. Whereas math creativity is traditionally associated with abstraction, clever proofs and calculation schemes, actuarial creativity will have more to do with reliable answers to open-ended or ill-defined real-life business problems that require approximations, modeling and additional assumptions to strictly make sense.

The second goal is how to teach creativity. The emphasis on speed and accuracy when applying a given method, while common in most courses that are meant to prepare students to pass actuarial exams, does not seem appropriate for promoting creative thinking and ought to be supplemented with activities where the focus is on the student's ability to deal constructively with ambiguity. If it is a class project, it should lead the student to carefully examine various sources of information and model different scenarios before eventually coming up with a rational and defensible answer (or range of answers).

There is no consensus on how to select or design suitable projects to cultivate creativity, but the following list of first principles is a good starting point:

- They should go beyond the theory learned in class.
- They should introduce ambiguity in terms of assumptions or methods.
- They should mimic real-life business problems, with realistic constraints on time and data.

One particular application of this approach is in the teaching of classes on loss modeling, ratemaking and loss reserving. There, one may start with the modeling of made-up data (perhaps mixtures or compound distributions), then of real loss data, then of big loss data. Through these activities, students will discover

that the theory taught in class should be approached critically rather than used in a plug ’n chug fashion. They will also be confronted with imperfect data and the limits of the statistical tools they are using (if in Excel), forcing them to seek creative ways to overcome these challenges.

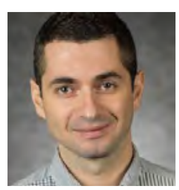
Real data are almost always more complicated than the theory would permit. For example, flood data can consist of normal events and catastrophic events, but the data may not allow disaggregation without a good amount of additional research. Further, there are spatial correlations, in the sense that when a hurricane hits Louisiana, it’s very likely to affect Mississippi or Arkansas or Texas as well. Students can use what they have been taught in class but should also be encouraged to go beyond these facts and investigate what theory and tools they really need to deal with the problem at hand, or what reasonable assumptions they can make that allow them to work out an answer.

Another dimension is the line of business: there are available loss data for personal and commercial auto, workers compensation, medical malpractice, product liability, flood insurance, marine insurance and so on, and each exhibits its own unique behavior in terms of loss development. Digging into the differences and the reasons for, say, the change in the speed of finalization of claims promotes a deeper appreciation of the subject and develops actuarial judgment. The same applies to credibility theory. Rather than specifying the method, why not try to test all of them and compare the results to common sense or explain the discrepancies?

Students may resist or resent these projects, since there is safety in a prescribed method and ambiguity often causes anxiety. But educators should refrain from giving a template of what the solution should look like. Instead, they may:

- Provide guidance if students are confused.
- Encourage experimentation and resourcefulness.
- Reward continuous improvement.
- Require clearly stated assumptions and sanity checks.

A last aspect concerns how to communicate creativity properly. Many students make the assumption that math and science classes are off limits for the grammar police, and sometimes they let go completely. It is our responsibility to reinforce that good writing is an indispensable skill that should be practiced at all times. Beyond spelling, grammar and syntax, consideration should be given to the editing of the text until it conveys the intended message with brevity and impact. Useful conventions of professional writing—such as a structure consisting of a summary, analysis and recommendations—should be insisted upon. Finally, the choice of graphs and visualizations should call attention to the important features of the data. ■



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ACTUARIAL RESEARCH CLEARING HOUSE
Call for Papers

The Actuarial Research Clearing House (ARCH) is an informal electronic publication presenting current actuarial research, which the Education and Research Section of the Society of Actuaries (SOA) offers to members and friends of the actuarial community. Unlike most professional presentations, ARCH is non-refereed. Its primary goal is the speedy dissemination of current thinking and aids to research rather than the publication of thoroughly edited papers. While the primary emphasis is on distribution of short notes or papers on specific research topics, ARCH also acts as a clearinghouse for items embodied in letters between researchers, useful computer programs (or announcements of the availability of such programs), translations of appropriate material in foreign languages, problems, solutions and so on. ARCH's editorial policy in brief follows.

The Education and Research Section of the Society of Actuaries will not be responsible for statements made or opinions expressed in the articles, criticisms and discussions in this publication. Editorial work is held to a minimum. We have balanced a normal desire to present reasonably worthwhile and cohesive material with our wish to allow anyone the opportunity of circulating their ideas to our readership. However, co-editors Charles S. Fuhrer and Arnold F. Shapiro reserve the right to cut, condense or rearrange information and cannot guarantee publication of either solicited or unsolicited material. In addition, authors are requested to preface their papers with a brief abstract (100 words or less). All items will be published on the SOA website with the name of the contributor, and the responsibility for the accuracy of all published material rests solely with the contributor.

Manuscripts should be prepared as a Word document or in Adobe Acrobat PDF format and submitted electronically. Prior to submission, please proofread your manuscript for typographical errors and set the margins to one inch on each side. Please submit your original manuscript to the SOA at *eschulty@soa.org*. ■

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