

**Research Internships and Graduate Education:
How applied learning provides valuable professional skills and development for
Canada's most highly trained students**

Rob Annan, PhD
Mitacs, Inc.

Prepared in cooperation with the Canadian Association of Graduate Studies

October 2012

Abbreviations and Acronyms

ANIP: Australian National Internships Program

ANRT: National Association of Research and Technology

BERD: Business Expenditure on Research and Development

CASE: Collaborative Awards in Science and Engineering

CIDA: Canadian International Development Agency

CNPq: National Council for Scientific and Technological Development (Brazil)

CONACYT: National Council for Science and Technology - Federal Agency

CSC: The China Scholarship Council

EPSRC: Engineering and Physical Sciences Research Council

FQRNT: Fonds québécois de la recherche sur la nature et les technologies

GDP: Gross Domestic Product

IAESTE: The International Association for the Exchange of Students for Technical Experience

IIS: Industrial Innovations Scholarship

IM-sKTPs: Industrial Mathematics shorter Knowledge Transfer Partnerships

IPS: Industrial Postgraduate Scholarships

IRDI: Industrial Research and Development Internship (Program)

KAIST: Korean Advanced Institute of Science and Technology

MOSPI: Ministry of Statistics & Program Implementation (India)

MSI: Ministry of Science and Innovation (New Zealand)

NIH: National Institutes of Health

NSERC: Natural Sciences and Engineering Research Council

OECD: Organisation for Economic Co-operation and Development

POSTECHL: Pohang University of Science and Technology

R&D: Research and Development

SMEs: Small and Medium Enterprises

SSSA: Scuola Superiore di Sant'Anna of Pisa

US Government's Student Career Experience Program (SCEP)

Executive Summary

Canada's university system is among the best in the world at providing leading-edge knowledge and technical skills to Canadian students. Nonetheless, there are growing concerns Canada's graduates – particularly those with post-graduate degrees – lack the diversity of skills required to transition effectively from academic training into professional careers. These concerns reflect the challenge facing universities, which are increasingly expected to provide professional and career skills training alongside traditional academic education. Given the well-documented shortcomings of Canadian innovation, as well as the employment difficulties for many of our post-graduate trainees, the need to equip our most highly-trained graduates with skills for professional success is more important than ever.

This report promotes research internships as a valuable complement to traditional graduate training with professional skills development. These internships complement academic education and technical skills training gained through traditional post-graduate programs with professional skills and experience that can be applied in careers in the industrial, academic, public, and not-for-profit sectors. They also have the advantage of promoting research collaboration between universities, not-for-profits and industry, resulting in greater opportunities for innovation through knowledge and technology transfer. This collaborative research directly serves participants while benefitting Canadian society indirectly through spillover effects including greater knowledge flow, increased skills adoption and promotion of a broader Research and Development (R&D) culture. They also build receptor capacity among Canadian organizations by demonstrating the benefits of working with highly-trained post-graduates. Finally, as a supplement to graduate education, these mechanisms do not require a major overhaul of the current system, preserving the acknowledged excellence of Canadian university research and graduate training.

Canada underproduces PhDs and Master's graduates relative to the more innovative economies of the Organisation for Economic Co-operation and Development (OECD); those we do produce are often ill-equipped to find employment outside academia in the private and not-for-profit sectors. Integrating professional skills training, non-academic experiential learning and professional network development through research internships provides necessary career guidance and support for these graduates.

Research internships also support increased innovation. Canada spends roughly 1% of our Gross Domestic Product (GDP) on business R&D - below the OECD average of 1.5% and well below the 2.0%-2.5% of leading countries. To remain competitive, Canadian businesses must increase research and innovation, in part by leveraging pre-existing strengths in Canadian universities. Innovation is also essential in the not-for-profit sector, which employs 12% of Canada's workforce and accounts for 7% of Canadian GDP. Graduate research internships are powerful agents for technology and knowledge transfer, boost business spending on R&D, expand receptor capacity for Canadian graduates, and strengthen ties between universities and other sectors.

Graduate internships support numerous positive outcomes. Benefits to students include:

- Experience working outside academia;
- Opportunity to gain and/or apply professional skills;
- Develop professional networks and gain mentorship beyond academic supervisors;
- Increased understanding of industrial and not-for-profit research needs for better applied research opportunities; and
- Provide user-group context and feedback for academic research projects.

Internships demonstrate the following to non-academic partners:

- The value of knowledge and technology transfer with Canadian universities;
- Applicability of specialized skills and knowledge to perform and manage research within a non-academic context;
- The benefit of expanding in-house research and innovation activities through low-risk, low-cost research internships, particularly in small and medium enterprises (SMEs) or not-for-profits without established R&D programs;
- The opportunity to train and test-drive potential recruits, and build relationships with universities for the identification of talent.

Research internship programs can act as a valuable corollary to traditional graduate education, providing students the opportunity to supplement academic knowledge and technical skills with valuable and applicable professional skills and experience. These students will be better equipped to transition effectively from post-graduate training into professional research careers, and will be more aware of potential career opportunities beyond academia. Furthermore, these programs help change the landscape of research and innovation in Canada through collaborative research projects that leverage academic strengths and boost business R&D activities; they support knowledge and tech transfer between academia and industry, and encourage R&D by Canadian firms by linking specific research challenges inspired outside of academia with expertise at Canadian universities.

Introduction

Graduate education has long provided exceptional knowledge and research skills to Canadian students. Canadian university researchers are among the world's best in publishing and impact, and provide teaching and mentorship to students who are trained at the leading edge of knowledge across the disciplinary spectrum.

Nonetheless, many graduate students find the transition from academic training to professional careers daunting. Students possess highly advanced technical skills and knowledge, but often lack many of the professional skills and experiences that allow their effective application in a working environment. This challenge is compounded by the recognition that Canada is producing too few graduate students relative to its economic peers. We thus face a dual challenge of increasing production of graduate students while ensuring their academic training prepares them for professional success.

Further compounding the problem, Canadian industry underinvests in R&D relative to its international peers, resulting in a well-recognized innovation and productivity gap. Despite a world-class university research system, Canada underperforms in numerous measures of innovation and productivity. The weak commitment to R&D by Canadian industry has resulted in underemployment for our most highly-educated graduates relative to counterparts in other countries.

This paper explores how research internships can provide a partial solution to these challenges. First, it provides a context for understanding the current challenges facing students in non-professional graduate programs: lack of professional skills training to prepare for non-academic careers and a paucity of opportunity to gain research experience in private industry and not-for-profit organizations. The paper also outlines the discourse around boosting innovation in Canada, and suggests that collaborative research through graduate internships is a valuable mechanism to increase productivity through innovation. It then provides an overview of how graduate internship programs operate, with an outline of key outcomes. Finally, the paper provides a non-exhaustive survey of graduate internship programs in Canada and other countries.

For reasons of focus and space, this paper does not investigate how professional graduate programs integrate internships or other professional work experience into their curricula, nor does it describe the numerous specific and targeted internship opportunities offered by specific companies, organizations, or government agencies. Internship programs for recent graduates are also omitted, since they are properly considered independent of graduate education, unlike internships that integrate with a student's research. This paper focuses instead on how graduate students in non-professional programs can gain professional skills and research experience in non-academic settings through research internships. While the omitted subjects shed light on the broader topic of experiential learning and are valuable topics in their own right, the author hopes to focus attention on how research internship programs can provide valuable skills and experience to graduate students in programs without a tradition of professional training, thus providing them with the tools for a successful transition from training to career.

Internships supplement graduate education with the opportunity to apply training in a non-academic context, gain essential skills, and build professional networks. These also serve as exceptional knowledge transfer mechanisms between universities and potential users of knowledge. Furthermore, internships underscore the benefits of hiring highly-educated graduates by industry and not-for-profits, thus increasing the receptor capacity for our most highly-trained students. These programs represent a positive supplement to Canadian graduate programs, providing valuable skills training and experience to our graduate students while supporting broader economic growth.

The Canadian Skills Crisis and Graduate Students

Navigating the pathway from graduate studies into a professional career is more important to the Canadian economy than ever. Canada is facing an acute skills crisis: an estimated two million skilled labour vacancies are expected across the country by 2031 (Miner, 2010). In the United States, an estimated 2.6 million new and replacement jobs will require graduate education by 2020 (Wendler et al, 2012). It is essential to our socioeconomic well-being that we produce the graduates who will meet that demand.

Canada awards fewer postgraduate degrees than our economic peers. While there has recently been signs of progress, Canada still produces far fewer PhDs per capita than most members of the OECD, ranking 23rd of 34 countries (OECD, 2012b). Numerous indicators are positively correlated with the rate of production of PhDs, including business investment in R&D and patents produced per capita. Canada ranks 14th out of 17 countries in patents per capita, and near the bottom in PhD graduation rate (Conference Board of Canada, 2011). It is essential that we continue to significantly increase enrolment in Canadian graduate programs if we want to ensure future competitiveness and productivity.

Paradoxically, Canadian PhDs face significant challenges finding jobs in industry and other non-academic sectors. Canadian organizations hire fewer PhDs than their counterparts internationally, and Canadian PhDs are, on average, paid less than their international peers (Boothe and Roy, 2008). And the problem is worsening: during the 1990s, the average wage earned by a PhD graduate in the US rose by 18%; in Canada it rose only 3%. The lack of uptake of PhD graduates by Canadian companies contributes to continuing lags in innovation and productivity (Boothby, 2011). Organizations miss out on the direct contribution these skilled graduates make to an organization's research and innovation activities, and also miss the indirect advantages gained by accessing cutting-edge knowledge and technology carried from our universities by recent graduates. Canadian organizations are thus less likely to be internationally competitive, world-leading, and responsive to fast-changing conditions. The skills crisis is even more acute as it pertains to graduate students: in many cases, organizations may not realize that they're lacking the requisite skills to innovate and remain competitive over the long term.

The poor receptor capacity in non-academic sectors has resulted in an oversupply of highly-trained candidates in the academic job market. Since 2001, doctoral enrolment has increased by 62% while the number of full-time faculty has increased approximately 20% (Crawley, 2010). This year, roughly 5,500 students will graduate with PhDs from Canadian universities, but less than half that number will be hired

in full-time academic positions. It is essential that we endeavour to find relevant work for these highly-skilled individuals by increasing the receptor capacity for graduate students outside academia.

Graduate Career Pathways and Skills Training

The current system of Canadian graduate education is largely premised on the model of traditional academic mentorship, where graduate students are equipped to follow their supervisors into academic research positions. This mentorship provides students with only a single example and single path for professional development. Given that Canada produces far more PhD graduates than necessary to fill vacant faculty positions, this approach is incomplete.

This problem is compounded by the observation that many graduate students are unaware of non-academic careers post-graduation. Recent studies have shown that graduate students in the United States are poorly informed about their career options: both what sorts of careers are available to them and the prerequisite skills for such careers (Wendler et al, 2012). This lack of information hurts the performance of graduate students seeking career alternatives, but also deters promising undergraduates from pursuing graduate degrees for which there are poorly understood career options.

In addition to the lack of awareness of career options, many graduate students lack the necessary skills, experience, and professional networks to allow them to transition effectively out of academia into other careers (most recently described in (OECD, 2012a)). Without a complementary foundation of skills in areas such as project management, communications, and business etiquette, graduate students are at a disadvantage when it comes to applying academic research skills in a non-academic environment where professional goals and pressures differ significantly. Furthermore, while graduate students build strong academic research networks, they often lack the breadth of a professional network that allows them to identify non-academic employment opportunities. These shortcomings hamper students' abilities to identify and pursue rewarding career opportunities where their training and knowledge can be effectively applied.

Clearly, there is an opportunity for change. It may be worth exploring, in some instances, whether grad programs can or should adapt to address some of the challenges in preparing students for careers post-graduation. This would require a major rethink of universities' mandates, with commensurate changes in infrastructure, staffing, and curriculum. There is also the risk that the strengths of Canadian research-based graduate education – intellectual rigour, research excellence, and academic performance – might suffer and weaken the system inadvertently.

An alternative is to create opportunities to supplement traditional graduate education with opportunities to gain these skills alongside regular education and training. This approach retains the strengths of the current system while filling important gaps. For instance, workshops or courses to support professional and soft skills development are now offered on most university campuses as valuable campus resources for students seeking to expand their professional skills. Universities may seek to adopt common national certifications or other credentials to certify these skills, thus providing students and employers the ability to quantify and recognize additional professional skills gained during

graduate study. A valuable recent survey of these campus professional skills offerings was prepared by Marilyn Rose (2012).

These professional skills courses are particularly effective when offered in conjunction with opportunities to apply the skills, such as through internships, co-ops, or in other professional settings. Offered together, skills workshops and internships complement each other to provide a well-rounded opportunity to learn and apply professional skills.

Canada's Innovation and Productivity Challenge

It is widely-acknowledged that Canada's performance in the broader innovation and research landscape lags its economic peers. Repeated studies point to the lack of business expenditure on R&D (BERD) as the major contributor to poor and worsening productivity (Expert Panel on Business Innovation, 2009; Science, Technology, and Innovation Council, 2010; Institute for Competitiveness and Prosperity, 2011; OECD, 2012a). Canada ranks 19th in the OECD in BERD, spending 1% of GDP, below the OECD average of over 1.5% and well below the 2%-3% of leading countries. Canada produces and hires fewer PhDs per capita than its economic counterparts, and files fewer patents (OECD, 2010; STIC, 2010). These shortfalls directly impact our productivity and threaten our continued economic well-being. It is clear that to maintain Canada's economic strength and higher standard of living, we must address these shortcomings.

Central to addressing these challenges will be the closer integration of university-based research with non-academic sectors. Leveraging our academic research strengths to boost industrial productivity and innovation is precisely the strategy recommended in a recent OECD report on the Canadian economy (OECD, 2012). This approach will also necessitate the increased production of highly skilled talent in our graduate schools and will require we equip these future innovators with the tools and experience to engage broadly in the Canadian economy. Expanding the scope and experience gained during education will help illuminate alternative career paths for our most highly educated, easing the transition out of academia and into the private and public sectors.

These needs are not confined to the private, for-profit sector. The Canadian not-for-profit sector plays an enormous role in ensuring a high quality of life for Canadians. Canada's not-for-profit sector accounts for more than \$100 billion in economic activity representing 7.0% of Canada's GDP (Statistics Canada, 2009). Innovation and productivity increases in this sector result in direct economic benefits through improved efficiency and novel processes as well as indirect economic benefits through improved health and social outcomes for Canadians.

Canada produces exceptional academic research, and government investment in R&D is among the world leaders. These advantages should be leveraged to support increased innovation across Canadian sectors and to address shortcomings, particularly in industry spending on R&D. Graduate research internships are an effective means of generating the knowledge transfer and receptor capacity to boost investment in research and innovation by Canadian industry and not-for-profits. Canada is already a world-leader in these areas, but much remains to be done. These require a continued shift in the means and methods of interaction between our universities and society at large.

Internships Increase Graduate Skills Training and Collaborative Research

We thus face a set of related challenges: Canada does not produce enough PhD and Master's graduates relative to the more innovative economies of the OECD, and those we do produce are ill-equipped to find employment outside academe in the private and not-for-profit sectors. Several factors contribute to this disparity: graduate students lack professional skills, experience and networks to complement academic training; there is a dearth of receptor capacity for highly educated graduates outside of academia, and there is a lack of commitment to research and innovation in Canadian industry and not-for-profit sectors.

Graduate research internships provide an opportunity to address these diverse challenges by creating intellectual bridges between universities and non-academic partners. Internships provide students with the opportunity to apply academic knowledge and expertise in non-academic settings and to obtain essential experience and valuable workplace skills. They also help students build professional networks outside academia, expose students to diverse career opportunities, and provide socio-economic context and feedback for academic research projects. Internships complement other approaches to gaining professional skills by providing a framework in which to apply them. Indeed, professional skills courses and workshops are exceptional supplements to internships, as the two approaches work in tandem.

Internships have the potential to demonstrate to Canadian industry and not-for-profits the value of research carried out by graduate students, illustrating how specialized skills and knowledge, and especially the ability to perform and manage research, are applicable in a non-academic setting. These programs often offer a low-risk, low-cost entree into R&D for organizations with little R&D capacity, in particular small and medium businesses or many not-for-profits. As such, these programs help make the case for increased hiring of graduate students by Canadian organizations, and serve to expand the receptor capacity for these graduates, expanding the overall commitment to innovation and research by Canadian organizations. Furthermore, given the increasing shift towards collaborative research design and support, these interactions help academics better understand the R&D needs of end-users and build valuable non-academic research networks.

Research internships do not represent a replacement for traditional academic graduate training, but can act as a valuable complement; not just for those students who have determined to pursue careers outside academia, but also for those who remain in academia, all of whom can benefit from professional skills development and from expanded professional links and networks.

Graduate internships – an overview

As described above, graduate internships support numerous positive outcomes:

- Experience working outside academia for students, and the opportunity to gain and/or apply professional skills;
- Increased receptor capacity for Canadian graduate students by demonstrating value of pursuing research and innovation activities outside academia;
- Expanded professional networks for interns and encourage mentorship beyond academic supervisors;

- Deeper academic understanding of industrial and not-for-profit research needs for better applied research opportunities;
- Leveraging of academic strengths to boost R&D activities at private and not-for-profit organizations through collaborative research;
- Increased knowledge and tech transfer between academia, industry and not-for-profits; and,
- Opportunity to test-drive potential recruits by organizations and a mechanism to build relationships with universities for the identification of talent.

Graduate research internships differ markedly from the undergraduate internship model in their higher order expectations and impacts as well as their commitment to research. Given their advanced training, graduate interns often transfer skills and knowledge into a firm where these didn't previously exist, or they supplement and expand existing skills and knowledge. Graduate internships are generally project-based, and designed to accomplish a specific research objective through the application of advanced skills and training. Through on-site interaction with the organization, interns gain research experience in a non-academic setting while building skills and networks. Graduate internships have a greater potential to deliver direct research outcomes and to boost an organization's research culture, including demonstrating the benefits of cutting-edge innovative ideas. Often, graduate internships serve as an opportunity for both intern and the non-academic partner to explore employment opportunities, and to determine whether there is a professional fit.

While internships are often designed for recently-graduated students, there are numerous advantages to performing internships concurrently with graduate studies. Concurrent programs allow the participation of an academic mentor and university resources, providing more comprehensive supervision for the student and supporting greater opportunities for knowledge and technology transfer. By coordinating graduate education and professional internship, the student is able to marry the academic and the practical to mutual benefit. Indeed, some graduate programs such as University of Toronto's M.Sc. in Applied Computing have begun integrating research internships as a core component of their programs. Ensuring academic rigour for the research project through peer-review ensures that the internship represents an applied supplement to a student's thesis project.

Research internships are distinct from industrial PhD programs. These programs, which are relatively well-established in Denmark, Germany, and other European countries, allow a student to earn a PhD while a salaried employee of a company. The student receives supervision from a university supervisor through regular meetings and must meet university requirements for graduation, but is primarily engaged on site with the company. While sharing many advantages with graduate research internships – particularly in gaining professional skills and learning the non-academic applications of research – these programs do not provide the training and education provided in a university environment. Furthermore, these programs do not involve the same degree of knowledge exchange, since the student has limited interaction with the university. Instead, these programs represent a means to gain a PhD while working in an industrial environment, whereas research internships are an opportunity to gain exposure and experience outside the university while retaining all of the advantages of a traditional, academic PhD.

Research internship programs remain a relatively new component of graduate education; indeed, Canada is leading the way. The federal government's Industrial Research and Development Internship

(IRDI) program has supported a national graduate internships program since 2008, supporting more than 3,000 internships in that time. The 2012 federal budget extended IRDI's support, now funding about 2,000 graduate internships annually, across all disciplines.

Mitacs-Accelerate is Canada's largest delivery agent for graduate research internships, active in this arena since 2003. Accelerate served as the model for the IRDI program and remains the primary delivery vehicle for the federal program. Additionally, Accelerate is supported by nearly all of Canada's provinces (it is not active in PEI), delivering 1,400 graduate internships nationally in 2011-12, a number set to rise to nearly 2,000 with the expansion of the IRDI program. Accelerate supports internships with all of Canada's research universities, across all disciplines, and with both industrial and non-industrial partners. The scope of the Accelerate program far exceeds equivalent programs in other countries; indeed, Accelerate has served as a model for both Britain and Australia, who are currently launching similar programs.

Internship programs do, however, exist in other countries, though often built along different models. In many countries there is a tradition of performing unpaid internships at companies during undergraduate years or following graduation. As with graduate internships, these represent an opportunity for inexperienced undergraduates to gain experience and add a level of professional expertise to their education, which is especially important since most undergraduate education does not have the inherent specialization and advanced skills of a graduate degree. For the company, internships are usually a mechanism to identify potential recruits and assess suitability in a relevant professional setting. Undergraduate internships are more akin to co-operative education programs, except they are generally organized and administered by the host company rather than coordinated by a dedicated university office, as with co-op.

In some countries and in specific industries, industrial graduate research internship opportunities with large companies are well-established. They represent a way for companies to plug into cutting-edge research coming out of universities, and especially to identify talent for recruitment. As such, graduate internships are common at leading-edge companies whose business requires constant infusion of new ideas and current state of the art technology and technique. Large companies including IBM, Microsoft, Siemens, Google, and Hewlett-Packard have long-standing internship programs, recruiting dozens of interns each year and providing them with opportunities to perform R&D in industrial environments.

SMEs, particularly those competing in high-growth areas at the fringes of the knowledge economy, can also benefit from this infusion of new ideas and approaches. Indeed, constant innovation is essential for these companies to compete and grow. However, these companies often lack the capacity to identify and cultivate collaborative relationships with appropriate university researchers, and lack the managerial capacity to establish effective internships. Furthermore, unlike large companies whose demand for research personnel is consistent, SMEs may have irregular needs and capabilities to host interns, making it difficult to develop strong relationships with universities. Without large HR departments and a culture of research management, internship programs are beyond the scope of most of these companies.

There are also numerous internship programs supported by various international governments. The US Government's Student Career Experience Program (SCEP), administered by the Office of Personnel Management, places students in academically-related positions in various federal departments while students are still in school. The program is not limited to graduate students, but is open to all students, including those in high school, vocational schools, and undergraduate programs. The Australian National Internships Program (ANIP) is also designed to place students in government positions during their studies. Open to undergraduates and graduates, ANIP offers academic credit for work performed in the Australian federal government or civil service or with non-governmental organizations. The Canadian government does not offer a broad internship program for current students. Programs such as the Management Trainee Program and the Accelerated Economist Training Program, and the Canadian International Development Agency's (CIDA) International Youth Internship Program are designed for recent graduates and do not integrate with a student's studies. These post-graduation internships are presented as recruiting tools rather than experiential learning opportunities that can support and extend academic study.

These internship programs – largely designed to identify and train potential employees - differ markedly from those designed as components of governments' innovation and skills strategies. These broader programs extend opportunities and benefits to a large number of small and medium sized businesses and smaller not-for-profits by supplying the organization and administration capacity not otherwise available. Broad, national programs also ensure sponsor's research needs are balanced by the educational needs of the student. National internship programs also allow governments to align the program with strategies for innovation, education, skills training, or other public policy objectives and to partner with universities to achieve educational goals. By leveraging private sector investment with public support, governments can encourage investment in parts of the innovation pipeline where industry traditionally under-invests, thus encouraging greater social benefit.

Despite the many advantages of graduate research internships, challenges remain. Many of these are cultural or traditional. Academics, and often students themselves, often favour traditional academic training that follows the academic career path of a university-based researcher. It is difficult to avoid the persistent notion that non-academic careers represent a "second-best" choice for many students. By the same token, there may be misconceptions in industry and the not-for-profit sector about the roles they can or should play in education and training, or about the pitfalls of working with academia. These misconceptions, from both sides, are in many cases based on outdated models. Global competitiveness in knowledge and the economy necessitates cross-sector collaboration and engagement.

Some of the challenges are also related to infrastructure and opportunity – in many areas, programs and processes to deliver internships on a widespread scale are, in many cases, not yet well-defined. This is changing, as many countries are now experimenting with coordinated programs at various stages of evolution. Despite these advances, given the changing nature of graduate education and the needs of the innovation economy, it is clear there remains much more capacity for these sorts of programs to supplement our existing strength in graduate education.

Conclusion

Graduate research internships represent a valuable opportunity to address a number of challenges. They provide graduate students pursuing non-professional degrees the opportunity to gain non-academic experience, develop career-relevant skills, and expand professional networks. At the same time, research internships provide a useful mechanism to promote collaborative research between academic researchers and organizations in the private, public and not-for-profit sectors. This is a significant opportunity to increase Canadian innovation and productivity by leveraging the acknowledged strength of Canada's academic research community. By offering internships as a corollary to graduate education, the strengths of academic training are preserved while broadening their potential application. Canada is a world-leader in promoting graduate research internships; with time, they may become an integral and valuable component of a well-rounded graduate education.

Canadian and International Case Studies of Existing Programs

The following is not an exhaustive list of graduate internship programs world-wide. Rather, it presents a selection of major government-supported programs and other broad-based programs aimed at graduate students in non-professional programs as case studies for how internships are delivered in other jurisdictions. Program details are provided where available.

Canada

The Natural Sciences and Engineering Research Council (NSERC) offers several industrial internship fellowships to Canadian graduate students and PDFs. [The Industrial Postgraduate Scholarships \(IPS\) program](#) supports Canadian graduate students who spend a portion of their graduate research (at least 20% of their time) working with industry. NSERC supports roughly 600 IPS students each year, with the annual costs shared between NSERC (\$15,000) and the sponsoring organization (\$6,000). (Note: in Quebec, NSERC delivers industrial internships in conjunction with the provincial funding agency Fonds québécois de la recherche sur la nature et les technologies (FQRNT) as the [Industrial Innovations Scholarship \(IIS\) program](#).)

The [Industrial R&D Internship \(IRDI\) program](#) provides graduate students and postdoctoral fellows the opportunity to apply academic research abilities to industry challenges while gaining valuable industry experience. IRDI currently supports 1,000 internships annually, though program funding was doubled in the 2012 federal budget. Targeting all academic disciplines, the program, which began in 2007, supports collaborative projects involving graduate students and postdoctoral fellows, their supervising professors, and industry partners. Companies share the cost of hosting the interns, with additional funding obtained from provincial, academic, and other partners. The IRDI program is modelled after the Mitacs-Accelerate program, which remains its primary delivery mechanism.

[Mitacs-Accelerate](#) connects businesses with graduate and postdoctoral students who apply their specialized skills to industry-identified challenges through peer-reviewed collaborative research projects. Students have the opportunity to translate their skills from theory into practice, while businesses gain a competitive advantage by accessing high-quality research expertise. Accelerate is supported by the federal IRDI program, federal regional development agencies, and by matching provincial and industrial funding. Currently, Accelerate delivers roughly 1,500 internships annually. Total government funding is matched 1:1 by company partners for the total \$15,000 internship cost, and interns spend roughly 50% of their time on-site at the company during the four to six month research project.

[Connect Canada](#) is a national internship program funded by IRDI that links Canadian companies with graduate students for research placements in the manufacturing, green technology and other key economic sectors. Connect Canada is managed by AUTO21 Inc. and the University of Windsor Centre for

Career Education. Connect Canada delivers up to 150 internships annually, with 50% of the \$10,000 internship cost paid for by the sponsoring partner.

The Leslie Dan Faculty of Pharmacy at the University of Toronto has established a [Graduate Industrial Internship Program](#) where graduate students spend three to four months prior to their graduating year at a pharmaceutical or biotech company to gain first-hand experience in an industrial R&D setting. Select students are paid a stipend by their host company for the duration of their internship.

United States

[Student Career Experience Program](#) is administered by the US government's Office of Personnel Management, and provides undergraduate and graduate students alike the opportunity to gain work experience directly related to a student's academic program. This program places students in numerous federal departments, including the Departments of Energy and Homeland Security. Internship lengths vary depending on circumstance.

[NIH Biotechnology Training Program](#) is a cohesive training program entailing cross-disciplinary research, a common curriculum composed of formal coursework in life science and engineering and of research seminars, and an industrial internship. The Program is funded by National Institutes of Health (NIH) with supplementary funds from the university partner. Program duration ranges from two to three years.

[Microsoft Research](#) offers internship opportunities at research locations around the world. The majority of interns are PhD students in the field of Computer Science, related technical majors, or social sciences with a technical focus, but Microsoft also accepts a small group of outstanding students with a proven research focus who are master's or bachelor's candidates. Internships at Microsoft Research provide students with the opportunity to apply research and theory to practice while working with well-known researchers and networking with fellow PhD students from around the world. Projects are a minimum of 12 weeks.

[AT&T Labs - Research summer internships](#) are offered to graduate students with an interest and experience in working on research problems. Research interns from universities across the US spend ten weeks at AT&T Labs Research working with technical staff members on research projects, presenting talks of their work at the end of summer. Applicants for summer internship may be members of an existing university collaboration or may apply as individuals. Candidates are typically graduate students but advanced undergraduates are also considered in exceptional cases.

Mexico

Internship program in enterprises for youth: This program supports Masters and PhD students in polytechnic schools who undertake 12 month internships with companies located in Mexico City. These students apply acquired knowledge in order to contribute to the process of technological development and innovation in the federal capital. This relatively new program is slated to run annually. In 2010 they accepted 31 students, 25 with master's degree and six PhDs. In 2011, 52 students were accepted, of which 49 masters students and three PhDs.

Mexico also supports **internships at national companies** to support and improve their technological and innovative capacity through research and development projects. The program is offered through [National Council for Science and Technology - Federal Agency \(CONACYT\)](#). CONACYT has a number of individual agreements with private companies in designated sectors for cross-training. Also available are Institutional Funds (monies between Universities and Institutes) to support one year stays of current university professors at private companies.

Australia

[Australian National Internships Program \(ANIP\)](#) provides academic credit for workplace research project in the public and not-for-profit sectors. ANIP places students from any discipline with Federal Parliament, Public Service, Legislative Assembly, or NGOs in capital region. ANIP is located on the campus of Australian National University in the nation's capital Canberra, and is open to undergraduate and graduate students, as well as Australian and international students.

[AMSI Industry Internship Program](#), administered by the Australian Mathematical Sciences Institute (AMSI), was launched with the assistance of Mitacs and is built on the Accelerate model. It involves a collaborative research project involving an industry partner, post-graduate or post-doctoral intern and an academic supervisor who collaborate on an industrial research project. The program is open to any of AMSI's 29 member universities and to Australian students and international students studying in Australia. The program will deliver roughly 100 internships annually.

[Industrial Transformation Research Program](#) was announced in December 2011 with first proposals opening mid-2012 and first centres scheduled to open in summer 2013. Delivered through the Australian Research Council, the program is designed to provide up to 600 doctoral and postdoctoral researchers the opportunity to work with industry partners, harnessing research capability to address industry needs.

New Zealand

[Ministry of Science and Innovation \(MSI\) Postgraduate Internships](#) support an average of seventy postgraduate students from science, technology, engineering, design or marketing. Those postgraduate students who have had exposure to commercialization (for example, through papers or practical experience) during their studies are eligible. Businesses receive funding to employ a postgraduate intern for up to six months to work on a challenging research and development project to develop a new product, process or service.

United Kingdom

[The Collaborative Awards in Science and Engineering \(CASE\) Studentship](#) is a PhD studentship during which the student enhances their training by spending between three and 18 months with an industrial sponsor in a workplace outside the academic environment. CASE studentship projects focus on an industrial research challenge and must provide sound training in research methods, and a stimulating intellectual challenge for the student. Both the research organization and the CASE partner nominate

supervisors responsible for overseeing the student's training. The co-operating body is required to make a financial contribution to both the student and the project. Internships are administered by any one of the seven UK research councils and are an integrated part of the PhD program. In some instances, students may spend an additional year in the program post-graduation as an employee of the company.

[Engineering and Physical Sciences Research Council \(EPSRC\) Industrial Doctorate Centres](#) offer four-year training programs that combine coursework and industrial research. Part of the broader Centres for Doctoral Training initiative, these industry-focused centres require students to spend roughly 75% of their time working directly with a company. Founded in 2009, 27 industrial training centres are now in operation, organized around research themes such as Biopharmaceutical Process Development and Optics and Photonics.

[Industrial Mathematics shorter Knowledge Transfer Partnerships, \(IM-sKTPs\)](#) are part Government-funded postgraduate internships that offer opportunities for companies to solve a business problem by working in partnership with leading academics and students from UK Universities. The program places a current UK-based PhD student into a company for a period of between three and six months, to carry out a stand-alone project that develops or exploits some capability in industrial mathematics.

European Union

[European Industrial Doctorates](#) are a new initiative by the European Union to increase collaboration between universities and businesses. In three year projects, students spend at least 50% of their time on site with a company partner working on an industrial research project. The initial call for proposals was in early 2012; EUR20 million is earmarked for this initiative.

[ERASMUS Student Work Placements](#) are part of the European Union's Lifelong Learners Programme, supporting students at higher education institutions to spend a placement (traineeship/internship) period between three and 12 months in an enterprise or organization in another participating country. Participating enterprises offer in-kind contribution including mentoring. Students can also apply for mobility grants to cover costs of living abroad.

[Marie Curie Fellowships](#) support the training and mobility of researchers throughout Europe. This program is particularly focused on the provision of post-doctoral level research training, but supports some projects for doctoral students. Fellowships can be located in academic or industrial settings in EU Member and Associated States. To participate researchers are required to go to another country to carry out their training.

[The International Association for the Exchange of Students for Technical Experience \(IAESTE\)](#) is a private non-profit and non-political student exchange organization. It provides students in scientific and technical degrees with paid, course-related, training abroad. With roughly 100 countries involved and exchanging over 4,000 job offers each year worldwide, it is the largest organization of its kind in the world. Member countries are responsible for the administration of the exchange in each own country.

France

[The CIFRE \(Industrial Agreements of Research Training\)](#) is an all-disciplinary program funded by the Ministry of Higher Education and Research which has entrusted the implementation of the program to the National Association of Research and Technology (ANRT). The program is based on an agreement between a company, a research laboratory and a PhD graduate. The company agrees to hire a PhD graduate for 36 months and assign a research paper in direct contact with a laboratory outside. The lab can be an established research laboratory at a university, a school, a public research organization, or a recognized research team, attached to a graduate school. Foreign laboratories are eligible under joint supervision with a French partner. This research is used to prepare a doctoral thesis.

[L'ABG-Intelli'agence](#) encourages and supports the development and expansion of scientific culture by facilitating the training, professionalization and employment of young scientists in laboratories, public institutions and companies both in France and abroad. Staff from higher education institutions (universities, doctoral schools and research institutions) provide mentorship to young PhDs. Advisors guide young PhDs in their professional integration. As a partner of these institutions, ABG supports the national advisor network and develops it on an international level in collaboration with the Franco-German University in Saarbrücken. Services offered by ABG-Intelli'agence include networking events, training sessions and résumé data-base.

Germany

[German Academic Exchange Service \(DAAD\)](#) supports the international exchange of students, academics and researchers. It is a registered association whose members are German institutions of higher education and student bodies. Its primary objectives include encouraging outstanding young academics from abroad to study or conduct research in Germany and enabling young German researchers to gain professional qualification at the best institutions around the globe. The DAAD achieves these goals with over 250 programmes which are largely funded by the Federal Government. Many of these involve industrial research internships, which are sometimes incorporated directly into graduate curricula.

Denmark

[The Industrial PhD Programme](#): A three-year, industrially focused PhD project where the student spends equal time with the company and university. Students are employed by the company, which receives a subsidy from the government. Students are also enrolled in a special business skills course. Established forty years ago, Denmark increased the enrolment from roughly 50 students per year to 100 students per year in 2002, and roughly 7% of Danish PhDs are enrolled in the program.

Spain

[ARGO GLOBAL Program](#): Provides financial support to new graduates from public or private Spanish universities to carry out professional internships with companies in Europe, the USA, Canada or Spanish companies with offices in Asia. ARGO GLOBAL is a program funded by the Spanish Ministry of Education

through the Directorate General for Universities. It is coordinated by the Foundation for the promotion in Asturias of the Applied Scientific Research and Technology (FICYT). ARGO GLOBAL expected to run from 2009 to 2012. During this period, a projected 1,100 grants were to be delivered.

The FARO Global Program: helps students in their last years of studies find employment through a six month internship in companies of member countries of the European Union, the USA, Canada and some Asian countries. The Fundación General de la Universidad de Valladolid (the Valladolid University General Foundation) currently promotes and administers the Faro Global programme. Students receive a grant (between 625 and 1,300 Euros, depending on the country of destination, paid by the Ministry of Education) which enables them to go abroad and increase their skills. The program involves significant collaboration with Spanish Universities and 1,050 students will benefit from the program over the next two years.

Italy

Italian SSSA Engineering Graduate Students: The Scuola Superiore di Sant'Anna of Pisa (SSSA) and FERMILAB offer a nine-week summer internship to outstanding graduate engineering students. In this comprehensive program interns work with scientists or engineers on projects related to Fermilab's research program. They also attend career planning and numerous training/informational sessions.

Russia

The scientific and scientific pedagogical personnel of innovative Russia program is a comprehensive program designed to attract youth to science, education, and high technology, and to retain and train highly-skilled personnel across the R&D spectrum. Not limited to internships, these comprehensive projects involve collaboration with universities, government, and industry. Currently, the program supports 2,200 projects annually.

Brazil

Doctoral Sandwich (SWI) Grants, administered by the National Council for Scientific and Technological Development (CNPq), support students formally enrolled in doctoral programs in Brazil, to complement their training through further research, development and innovation with a Brazilian company. Projects are 3-6 months in duration.

Postdoctoral Business (PDI) Grant: Enables researchers to consolidate and update their knowledge as well as further their research, development and innovation in with a company to increase competitiveness. Projects are 6-12 months in duration.

India

At present, no national graduate-level internship programs exist; programs do exist for undergraduate students in BTech programs. Indian Institutes of Technology at Bombay is in the process of establishing

an industrial internship program for PhD students. IIT Bombay is currently considering whether to extend the program to Master's students in the MTech program.

Government internship programs exist in India within specific ministries. For instance, the [Ministry of Statistics & Program Implementation \(MOSPI\)](#) offers 210 two-month post-graduate internships annually in mathematics, statistics, demography, and associated fields. Likewise, the **Government of India Planning Commission** also hosts post-graduate research internships.

Korea

[Pohang University of Science and Technology \(POSTECH\)](#), administers an industrial internship program in partnership with IAESTE (*see European Union above*) to provide students with field experience to supplement their academic training. Through this program, students are hired by institutions or companies in IAESTE member countries to work in an industry relevant to their studies.

[Korean Advanced Institute of Science and Technology \(KAIST\)](#) include internships as a component of their degree program, giving double weighting to international internships vs. national internships. Most of KAIST's exchange agreements are established for undergraduate student exchange only. However, some faculties have entered into exchange agreements that include or focus specifically on graduate coursework exchanges.

China

[The China Scholarship Council \(CSC\)](#) is a non-profit institution affiliated with the Ministry of Education that provides financial assistance to the Chinese citizens wishing to study abroad and to foreign citizens wishing to study in China. These scholarships are designed to develop the educational, scientific and technological, and cultural exchanges and economic and trade cooperation between China and other countries.

References

- BMO Bank of Montreal.** (2012). *Canadian Business Look for Post-secondary Education When Hiring – BMO Report* [News Release]. Retrieved from <http://newsroom.bmo.com/press-releases/canadian-businesses-look-for-post-secondary-educat-tsx-bmo-201205240792844001>.
- Boothby, D** (2011) *Recent Doctoral Graduates In Canada And The U.S.A: Indicators From The Canadian And U.S. Surveys Of Earned Doctorates*.
- Boothe, P and R Roy.** (2008). "Business Sector Productivity in Canada: What do we Know?" *International Productivity Monitor*, 16: 3-13.
- Conference Board of Canada** (2011), *Hot Topic: Advanced Skills and Innovation*. <http://www.conferenceboard.ca/hcp/hot-topics/innovation.aspx> (Accessed June 2011)
- Crawley, A.** (2010). "A postdoctoral crisis in Canada: From the "Ivory Tower" to the Academic "Parking Lot". Retrieved from <http://www.cags.ca/media/docs/Conf/2010/CAGS%20mtg%20in%20Toronto%202010%20presentation.CRAWLEY.pdf>
- Expert Panel on Business Innovation** (2009), *Innovation and business strategy: why Canada falls short*.
- Institute for Competitiveness and Prosperity** (2011) *Canada's innovation imperative*.
- Miner, R.** (2010). *People without jobs, jobs without people: Ontario's Labour Market Future*. Retrieved from http://www.collegesontario.org/research/research_reports/people-without-jobs-jobs-without-people-final.pdf
- OECD.** (2010). *Measuring innovation: A New Perspective*
- OECD.** (2012a). *OECD Economic Surveys: Canada 2012*, OECD Publishing.
- OECD.** (2012b). *Education at a Glance 2012*, OECD Publishing.
- Paglis, L., Green, S. G., & Bauer, T. N.** (2006). Does adviser mentoring add value? A longitudinal study of mentoring and doctoral student outcomes. *Research in Higher Education*, 47(4), 451-476.
- Peterson, S. & Marsh, R.** (2010). MITACS Accelerate: A Case Study of a Successful Industrial Research Internship Program. *EIMI 2010 Proceedings*. 411-418
- Rose, M.** (2012), *Graduate Student Professional Development: A Survey with Recommendations*.
- Science, Technology, and Innovation Council (STIC)** (2010), *State of the Nation 2010, Canada's Science, Technology, and Innovation System*.
- Statistics Canada** (2009), *Satellite Account of Non-profit Institutions and Volunteering*.
- Taylor, J. M., & Neimeyer, G. J..** (2009). Graduate school mentoring in clinical, counseling, and experimental academic training programs: An exploratory study. *Counseling Psychology Quarterly*, 22(2), 257-266.

Wendler C, B Bridgeman, R Markle, F Cline, N Bell, P McAllister, and J Kent. (2012). *Pathways Through Graduate School and Into Careers*. Princeton, NJ: Educational Testing Service.