J Technol Transf
DOI 10.1007/s10961-014-9341-3

Teaching technology commercialization: introduction to the special section

Andrew J. Nelson · Erik Monsen

Over the past three decades, attention towards the commercialization of university research, academic entrepreneurship, and university–industry relations has increased dramatically (Bercovitz and Feldman 2008; Mowery et al. 2001; Nelson and Byers 2005; Siegel et al. 2007). Pedagogical developments—namely, "how to teach technology commercialization"—lie at the heart of this transformation and present some of the primary challenges and opportunities in the classroom and for shaping activity more generally. Correspondingly, this special section of the *Journal of Technology Transfer* grew from a Professional Development Workshop (PDW) at the 2012 meeting of the Academy of Management. Panelists—including the authors of the papers in this section—and attendees alike discussed both the challenges and the opportunities that accompany efforts to teach technology commercialization.

Mitchell and Singh (1996: 170) define technology commercialization as "the process of acquiring ideas, augmenting them with complementary knowledge, developing and manufacturing saleable goods, and selling the goods in a market." As such, technology commercialization encompasses a broad range of activities, including startups, spinouts, licensing, collaboration, contract research, consulting and open innovation. (For corresponding literature reviews, see Bozeman 2000; Debackere and Veugelers 2005; Link and Siegel 2005; Markman et al. 2008; Rothaermel et al. 2007; Siegel 2009).

Given the breadth of technology commercialization activities, developing educational resources on technology commercialization is not as simple as repackaging an existing entrepreneurship or new product development course. (See, for example, Barr et al. 2009; Clarysse et al. 2009; Phan et al. 2009; Siegel 2009; Thursby et al. 2009.) Instead, the multiple activities, stakeholders and disciplines involved in the technology commercialization process necessitate new content and approaches. For example, education efforts need to address the challenge of bridging between a variety of different groups, including:

A. J. Nelson (✉)
University of Oregon, Eugene, OR, USA
e-mail: ajnelson@uoregon.edu

E. Monsen
University of Strathclyde, Glasgow, UK

Published online: 24 May 2014

- Researchers who are focused on basic science and technology,
- Commercial businesses who are focused on products, performance and profits,
- Universities, government laboratories and other research organizations who employ researchers and may own intellectual property, and
- Research funding and governmental organizations that attempt to accelerate the number, pace and success of technology commercialization attempts.

Moreover, participants in technology commercialization vary along a number of dimensions, including personal motivation, educational and hierarchical level, disciplinary background (e.g., business, engineering, science, medicine, etc.), and work experience. Thus, different groups and participants bring different skills, resources, priorities and insights. In turn, education efforts must reach across potential boundaries to integrate these diverse perspectives.

Challenges associated with bridging and leveraging this diversity are accentuated by the fact that many of the core ideas underpinning technology commercialization are themselves disconnected in the scholarly literature. For example, in 2009 the first author collected data on scholarly articles published on entrepreneurship education and on technology transfer, two areas with obvious relevance to the teaching of technology commercialization. The database included 85 articles on entrepreneurship education and 242 articles on technology transfer. He then coded these articles according to their dominant themes and constructed "networks" between themes, such that each theme was a node in the network and discussion of multiple themes in a given article resulted in a line or connection between nodes. In short, the review provided a visual indication of which themes were prevalent in each of these two literatures and which themes were discussed alongside which other themes.

A striking finding from this exercise, reproduced in Fig. 1, is that the entrepreneurship education and technology transfer literatures focus on distinctly different thematic areas. In entrepreneurship education, on the one hand, course design and approach, learning processes, demographics, and student attitudes are dominant themes. In technology transfer, on the other hand, technology transfer offices, policies, intellectual property, university–industry relations, and revenue are dominant themes. In fact, only three of the 54 total themes—economic growth, startups, and productivity assessment—appear in both literatures. (These themes are the three nodes that connect the two networks in Fig. 1.) Moreover, just 2 of the 85 entrepreneurship education articles (2-percent) mention technology transfer at all, and only 6 of the 242 technology transfer articles (also 2-percent) mention education.

By and large, the two literatures are published in separate places, too: Only 31 of the 85 entrepreneurship education articles (36-percent) were published in journals that also publish technology transfer articles, and only 41 of the 242 technology transfer articles (17-percent) were published in journals that also publish entrepreneurship education articles. In other words, 64-percent of entrepreneurship education articles and 83-percent of technology transfer articles were published in journals that do not publish research in both areas. Finally, the vast majority of article authors contributed to only one of the two research areas: Fewer than 1-percent of the authors in the sample (five of 515) had published articles on both entrepreneurship education and technology transfer. In short, these two obviously connected literatures are almost completely disconnected in practice.

The 2009 publication of a special issue of the *Academy of Management Learning and Education* on "technology management education" helped to address some of this disconnect between technology transfer and education (Siegel 2009). Subsequent work, too,

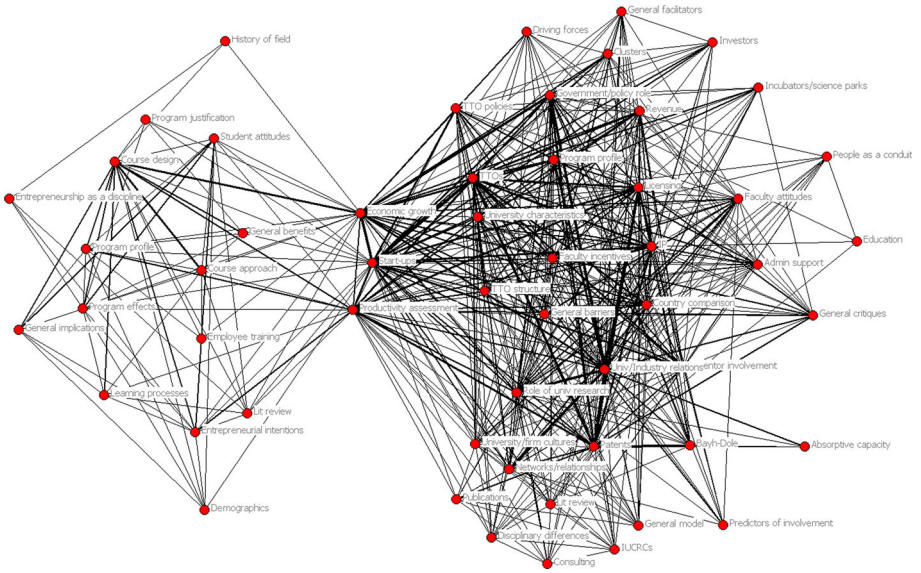

Fig. 1 Relationships between themes in the entrepreneurship education (*left*) and technology transfer (*right*) literatures

has reinforced the fruitfulness of integrating thinking across these topics. (See, for example, Nelson and Byers 2014; Winkel 2013.) Nonetheless, the overall emphasis of each literature suggests little change in the most recent period from the situation depicted in Fig. 1.

In the spirit of bridging gaps to develop further insights into technology commercialization education, our 2012 Academy of Management PDW engaged educators from a variety of disciplines and backgrounds, including business, science and engineering. The three papers in this special section represent exemplary contributions that stemmed, initially, from PDW presentations by the authors, and that the authors subsequently refined on the basis of the PDW discussion and feedback from peer reviews as part of the publication process.

In the first article, "The Business of Translation: The Johns Hopkins University Discovery to Market Program," Phil Phan analyses the case of a unique recently-developed year-long practice-based technology commercialization program at Johns Hopkins University's Carey Business School. Phan grounds his analysis in recognition of the non-linear path of invention, the inherent multi-disciplinarity of commercialization, and the important role played by institutional context in shaping particular approaches. He then describes how the understanding-focused design principles, the required human and intellectual resources, and the program structure and project deliverables of the Johns Hopkins program incorporate these aspects to promote successful technology commercialization.

In the second article, "The University is the Classroom: Teaching and Learning Technology Commercialization at a Technological University," Jonathan Levie provides a historical overview of technology commercialization in Glasgow, Scotland, and in particular at the University of Strathclyde, covering the period from the eighteenth century to the present. Levie emphasizes the role of a comprehensive university entrepreneurial ecosystem in technology commercialization and argues that the focus should be on

learning instead of teaching, and that technology commercialization can be learned in many ways, of which the classroom is but one option. Nonetheless, he discusses practical and theoretical issues concerning the teaching of commercialization across university faculties and up-and-down the academic hierarchy. In doing so, he stresses that commercialization at Strathclyde depends upon a wide portfolio of activities that engage a broad range of stakeholders.

Engaging the broader university entrepreneurship ecosystem is also central to the third and final article, "Parting the Ivory Curtain: Understanding How Universities Support a Diverse Set of Startups," by Sonali Shah and Emily Cox Pahnke. Through four illustrative case studies of successful start-ups affiliated with Stanford University, Shah and Cox Pahnke portray the wide variety of university-linked startups. They also propose a framework that identifies four types of university entrepreneurship, based upon the specific technology development and entrepreneurial education resources used. In turn, this framework reveals gaps in the literature on university entrepreneurship and opportunities for educational initiatives to have positive impact.

Each of the articles, therefore, provides fruitful examples of how specific leading universities have approached the teaching of technology commercialization. The approaches themselves differ—appropriately, since a common theme in each article is the importance of diverse activities and participants, and an emphasis upon sensitivity to context. Thus, these articles do not provide a "one-size-fits-all" recipe for how to conduct technology commercialization education; rather, each article offers a clear conceptual framework and deep illustrations of how a particular university has successfully engaged in the teaching and promotion of technology commercialization.

Despite their uniqueness, one common theme has emerged from these three articles: Although this special issue emerged from a conference workshop designed to discuss the classroom teaching of technology commercialization, all three articles suggest that the classroom teaching is not sufficient for successful university entrepreneurship and technology commercialization; rather, all three articles emphasize the importance of understanding and leveraging the broader university commercialization ecosystem. In particular, they stress the need for close partnerships between the technology commercialization office and the educational process, as well as close linkages between science, engineering, business, law and other groups. Furthermore, in order for the classroom experience is to be sustainable and impactful in the longer term, it is important to engage in these collaborations not only during the classroom experience, but also before and after it.

In addition to helping to bridge the earlier identified gap between the entrepreneurship education and technology commercialization literatures, these articles also suggest several areas for future research and pedagogical development. First, if technology commercialization should be part of the greater university ecosystem, where should the activities be focused and who should take the lead on coordinating the activities? For example, are these activities better housed in an academic faculty such as business, engineering or science? Or might it be better to coordinate these activities through a non-academic professional unit such as the technology transfer office? In this regard, it would be informative to draw on related configurational research in the area of corporate entrepreneurship (Burgers et al. 2009; Covin and Miles 2007; Hill and Birkinshaw 2008; Miles and Covin 2002).

Second, are there conceptual frameworks that can provide a sounder theoretical foundation for the pedagogy of teaching technology commercialization? For example, in this special issue, Phan draws on Bloom's taxonomy of learning (Richard 1985) and Levie draws on single and double loop learning (Argyris 1993, 2002). Other recent articles on entrepreneurship education draw on a range of potentially informative perspectives,

including but not limited to human capital theory (Volery et al. 2013) and structuration theory (Morris et al. 2013). In order to bridge the aforementioned gaps between technology commercialization and entrepreneurship education, we encourage more conversations and engagement between entrepreneurship on one hand and innovation/technology management on the other.

Third, a key question that emerged from the workshop and that remains unanswered concerns how a university can engage in the teaching of technology commercialization if it does not have financial resources of the universities described in the three articles. In other words, how can a technology commercialization class be developed and taught with more limited financial resources, and yet still be successful and impactful in the longer term? We encourage readers of this editorial to carefully consider this parting question, as this is a central challenge to promoting technology commercialization across the broadest possible range of institutions of higher learning.

References

Argyris, C. (1993). *Knowledge for action: A guide to overcoming barriers to organizational change*. San Francisco: Jossey-Bass.

Argyris, C. (2002). Double-loop learning, teaching, and research. *Academy of Management Learning & Education, 1*(2), 206–218.

Barr, S. H., Baker, T., Markham, S. K., & Kingon, A. (2009). Bridging the valley of death: Lessons learned from 14 years of commercialization of technology education. *Academy of Management Learning and Education, 8*(3), 370–388.

Bercovitz, J., & Feldman, M. (2008). Academic entrepreneurs: Organizational change at the individual level. *Organization Science, 19*, 69–89.

Bozeman, B. (2000). Technology transfer and public policy: A review of research and theory. *Research Policy, 29*(4/5), 627–655.

Burgers, J. H., Jansen, J. J. P., Van den Bosch, F. A. J., & Volberda, H. W. (2009). Structural differentiation and corporate venturing: The moderating role of formal and informal integration mechanisms. *Journal of Business Venturing, 24*(3), 206–220.

Clarysse, B., Mosey, S., & Lambrecht, I. (2009). New trends in technology management education: A view from Europe. *Academy of Management Learning and Education, 8*(3), 427–443.

Covin, J. G., & Miles, M. P. (2007). Strategic use of corporate venturing. *Entrepreneurship Theory & Practice, 31*(2), 183–207.

Debackere, K., & Veugelers, R. (2005). The role of academic technology transfer organizations in improving industry science links. *Research Policy, 34*(3), 321–342.

Hill, S. A., & Birkinshaw, J. (2008). Strategy-organization configurations in corporate venture units: Impact on performance and survival. *Journal of Business Venturing, 23*(4), 423–444.

Link, A. N., & Siegel, D. S. (2005). University-based technology initiatives: Quantitative and qualitative evidence. *Research Policy, 34*(3), 253–257.

Markman, G. D., Siegel, D. S., & Wright, M. (2008). Research and technology commercialization. *Journal of Management Studies, 45*(8), 1401–1423.

Miles, M. P., & Covin, J. G. (2002). Exploring the practice of corporate venturing: Some common forms and their organizational implications. *Entrepreneurship Theory & Practice, 26*(3), 21–40.

Mitchell, W., & Singh, K. (1996). Survival of businesses using collaborative relationships to commercialize complex goods. *Strategic Management Journal, 17*(3), 169–195.

Morris, M. H., Webb, J. W., Fu, J., & Singhal, S. (2013). A competency-based perspective on entrepreneurship education: Conceptual and empirical insights. *Journal of Small Business Management, 51*(3), 352–369.

Mowery, D. C., Nelson, R. R., Sampat, B. N., & Ziedonis, A. A. (2001). The growth of patenting and licensing by US universities: An assessment of the effects of the Bayh-Dole Act of 1980. *Research Policy, 30*, 99–119.

Nelson, A. J., & Byers, T. (2005). Organizational modularity and intra-university relationships between entrepreneurship education and technology transfer. In G. Libecap (Ed.), *University entrepreneurship*

and technology transfer: Process, design, and intellectual property (pp. 275–311). Stamford, CT: Elsevier Science/JAI Press.

Nelson, A. J., & Byers, T. (2014) Challenges in University technology transfer and the promising role of entrepreneurship education. In A. Link, D. Siegel, & M. Wright (Eds.), *Handbook of University Technology Transfer* Chicago, IL: University of Chicago Press, *forthcoming*.

Phan, P., Siegel, D., & Wright, M. (2009). New developments in technology management education: Background issues, program initiatives, and a research agenda. *Academy of Management Learning and Education, 8*(3), 324–336.

Richard, P. (1985). Bloom's taxonomy and critical thinking instruction. *Educational Leadership, 42*(8), 36–39.

Rothaermel, F. T., Agung, S., & Jiang, L. (2007). University entrepreneurship: A taxonomy of the literature. *Industrial and Corporate Change, 16*, 691–791.

Siegel, D. (2009). From the guest editors: New developments in technology management education. *Academy of Management Learning and Education, 8*(3), 321–323.

Siegel, D., Wright, M., & Lockett, A. (2007). The rise of entrepreneurial activity at universities: Organizational and societal implications. *Industrial and Corporate Change, 16*, 489–504.

Thursby, M., Fuller, A., & Thursby, J. (2009). An Integrated approach to educating professionals for careers in innovation. *Academy of Management Learning and Education, 8*(3), 389–406.

Volery, T., Müller, S., Oser, F., Naepflin, C., & del Rey, N. (2013). The impact of entrepreneurship education on human capital at upper-secondary level. *Journal of Small Business Management, 51*(3), 429–446.

Winkel, D. (2013). The changing face of entrepreneurship education. *Journal of Small Business Management, 51*(3), 313–314.