FAILURE, ANOMALIES, AND SERENDIPITY: NAVIGATING THE COMPLEXITIES OF TECHNOLOGY TRANSFER THROUGH STORYTELLING

„Life can only be understood backwards; but it must be lived forwards."

Søren Kierkegaard

ABSTRACT The definitions of technology transfer have evolved over time. In fact, the terminology has shifted from technology to knowledge transfer or even knowledge valorization. This change reflects the (r)evolution that has happened: we now understand that the process is about so much more than just the one-directional movement of technology. Instead, the process is now frequently described as sharing and using of knowledge in its various forms as they vary across different scientific disciplines. What all these descriptions share is the understanding that technology transfer is inherently complex, dealing with advanced technologies that are not always easily adapted. One way of better addressing several aspects of these complexities, is through the use of storytelling.

One might argue that since the Bayh-Dole Act in the 80s enabled and propagated formal technology transfer, we have inadvertently overlooked other forms of technology transfer. Several authors note that despite expanded definitions in literature, the prevailing processes within universities remain very formal and IPR-centered (Link et al., 2007). Such an IPR-centric view can limit the understanding and scope of what technology transfer truly entails, potentially overlooking other valuable forms of knowledge and innovation that do not fit neatly within traditional IPR definitions.

KNOWLEDGE TRANSFER OFFICE AT THE UNIVERSITY OF LJUBLJANA

Formal processes at the Technology Transfer Offices are organized as a linear process, starting with scientific discovery and culminating in market entry. The Knowledge Transfer Office at the University of Ljubljana is no exception. We expect our researchers to disclose their invention; then their invention is assessed, and protected, and steps are taken towards commercialization. There are internal mechanisms in place to help speed up and streamline this process, such as an internal P.O.C fund, collaborations with mentors, incubators, and more.

However, in our office's everyday dealings, this one-directional narrative exists only on paper. The reality is far more complex. The second most significant breakthrough, after the scientific discovery itself, is determining where and how the invention can be applied. The actual process is revealed to be

The main building of the University of Ljubljana. Source: iStock.com/ShevchenkoAndrey.

fraught with failures, anomalies, and moments of serendipity, and it is in no way a straight road. Rather than concluding at market entry, a new aspect of the technology transfer process begins there, and commercialization can be seen as the first step in realizing the full potential of the invention.

UNDERSTANDING THE PROBLEM: A COMPARISON TO STARTUPS

This aligns with the startup world and the lean method it personifies, where the process starts with identifying the problems of the customers and then creating and selling the solution. Startup founders do market research before starting any product development, often pre-selling products that only exist on paper or in their heads. Market feedback is used to further refine the product. The process is iterative and non-linear by definition, involving numerous feedback loops and collaborative efforts across various sectors.

In contrast to formal processes, these can also be described as informal technology transfer, which expands beyond contractual dealings and involves more personal and less structured interactions. Both formal and informal mechanisms are crucial for effective technology transfer, as they complement each other by enhancing the overall quality and applicability of the transferred technology (Link et al., 2007; Grimpe & Hussinger, 2008). Azagra-Caro (2020) recognizes even works of literary fiction as a form of knowledge transfer. Building on Link et al. 2007 taxonomy, she suggests a third way knowledge is transferred – non-formal. This includes literary fiction or storytelling that can serve as a very efficient medium for conveying very complex scientific ideas and achievements in a format accessible to the public. They can also have a significant impact.

EXAMPLES OF NON-LINEAR APPROACHES

A prime example of a non-linear approach was Steve Jobs, an icon in the technology world. He was famous for being vehement about creating the market need rather than simply recognizing it. On the day he unveiled the Macintosh, a reporter from Popular Science asked Jobs what type of market research he had done. Jobs responded by scoffing, „Did Alexander Graham Bell do any market research before he invented the telephone?" (Isaacson, 2011).

Technology transfer offices must move beyond the linear progression as implied by the Bayh-Dole Act and the reversed process of product development in the startup world. Inventions cannot be simply transferred to the market, nor can they really count on market research, as they are ahead of the market. Instead, in technology transfer, both processes are intertwined, creating a more complex and dynamic approach.

THE ROLE OF FAILURE AND SERENDIPITY

When we factor in patent search reports, feasibility studies, clinical trials, and other assessments, the process becomes even more intricate and subject to several feedback loops all influencing each other. In this complex environment, failures, errors, and moments of serendipity are not just obstacles but integral components that reshape, reinforce, and refine the original ideas, making them stronger in the process.

As such, failure is not just inevitable but a crucial learning opportunity, where we use the knowledge gained at failure to make a better next attempt. This iterative cycle mirrors the experimental nature of the scientific method itself. Mistakes reveal the limitations of current approaches and provide invaluable insights for future endeavors. Early failures highlight fundamentally flawed assumptions, and the further along the complex journey from the lab to the market, the more we move from barely functional to perfect.

KNOWLEDGE OPPORTUNITY: A NEW LAYER OF COMPLEXITY

As if this process was not difficult enough, there is, however, (at least) another layer of complexity in the technology transfer realm. Namely, great scientific discoveries often redefine our very understanding of the world. Let us consider the case of „dark oxygen," a scientific discovery that has dominated the news and my social media recently. A multidisciplinary team of scientists led by Andrew K. Sweetman reported that oxygen can be generated in the seafloor under conditions where such production was deemed impossible. Before this discovery, the scientific community considered photosynthesis to be the Earth's only notable source of oxygen (Sweetman et al., 2024).

The discovery of „dark oxygen" has fundamentally transformed our understanding of oxygen production, and by extension, the origins of life on Earth itself. No wonder the lead scientist himself suspected faulty sensors when they first got the data back. Major scientific discoveries like this lend themselves well to the „paradigm-shifting" language of Thomas Kuhn. According to Kuhn, scientific progress is not a linear accumulation of knowledge but rather a series of transformative shifts in our understanding of the world. These shifts occur through a process that begins with „normal science," where the dominant paradigm governs research and problem-solving activities.

Over time, anomalies—observations or problems that cannot be explained by the existing paradigm—accumulate. These anomalies become more and more difficult to explain within the existing paradigm – but the normal scientists, as Kuhn calls them, are usually unable to see beyond it. As these anomalies become more significant, so do the solutions explaining them away. The ever more complicated solutions start to erode confidence in the current paradigm, leading to a crisis. Eventually, a new paradigm emerges, offering a more comprehensive understanding and solving the anomalies, thereby establishing a new period of normal science. It is not unusual for the new paradigm to come from an outsider, somebody willing to do things differently, undisturbed and unbiased by the prevailing paradigm.

These shifts that Kuhn describes are not gradual; they are revolutionary. They turn the world upside down until the revolutionary novelty in understanding becomes the new paradigm. In this environment, technology transfer professionals must be adept at managing both the push and pull forces while anticipating and navigating the paradigm shifts that redefine the landscape. This involves not just moving innovations from the lab to the market but also preparing the market for the transformative impact of these innovations.

Navigating New Horizons: Collaborative Visits to Port Luka Koper by Students, Startups, and Researchers
Source: Uniminds.si.

THE ROLE OF STORYTELLING IN TECHNOLOGY TRANSFER

Another lengthy quote by Steve Jobs further illustrates this point: „Some people say, 'Give the customers what they want.' But that's not my approach. Our job is to figure out what they're going to want before they do. I think Henry Ford once said, 'If I'd asked customers what they wanted, they would have told me, 'A faster horse!' People don't know what they want until you show it to them. That's why I never rely on market research. Our task is to read things not yet on the page" (Isaacson, 2011).

As we have seen, in Jobs' eyes, a true innovator is not just a particularly lucid observer of the paradigm shift but, to a large extent, a catalyst for it. Innovators create something that fundamentally alters the existing paradigm, causing the shift to happen. Innovators are visionaries, capable of seeing and creating outside their immediate context. If we want to see more groundbreaking technologies reach the market, then it must be the job of technology transfer officers to complement those skills if the inventors are lacking in them.

THE TIMING OF INNOVATION

The more inventions are pioneering, the more they outpace customer demand, and their impact on the market can only be assessed in hindsight. The innovative process thus demands being one step ahead, with the understanding that the appreciation and success might take quite some time, depending on how long the world will need to catch up to the vision. Here, let me draw on Kierkegaard's aphorism, „Life can only be understood backwards; but it must be lived forwards," as it perfectly describes the paradox of retrospective understanding and forward-facing action that we face daily in technology transfer.

That is to say, innovation often outpaces the solutions to current problems, not (yet) solving challenges that we have and addressing challenges that we cannot even recognize yet. This mismatch in timing illustrates the complexity of the world technology transfer. Technology transfer is sailing willingly into uncharted territory, equipped only with our understanding of the past journeys, not the waters we are currently navigating.

THE PRACTICALITY OF STORYTELLING

In essence, storytelling not only serves as a practical tool but also resonates with the deeper understanding of how we navigate and make sense of innovation. As Kierkegaard's philosophy suggests, while the full impact of these technological advances may only be understood in retrospect, the forward-looking narrative crafted through storytelling can bridge the gap between invention and market readiness, ultimately guiding innovations through the tumultuous and often serendipitous path from the lab to real-world application.

But why is this so important? In the context of inventions and technology transfer, we often find ourselves at the forefront of these paradigm shifts. Our role involves identifying, developing, and commercializing innovations that may still be in the anomaly phase, ahead of widespread acceptance. In technology transfer, aligning research with market needs is key, but as Jobs showed, true success comes when technology reveals the needs that society didn't know it had.

This pioneering position inherently presents significant challenges. The market is frequently unprepared for these advanced technologies, leading to resistance and slow adoption. The difficulty lies not in the innovation itself but in the timing—technology transfer professionals must navigate the precarious gap between groundbreaking scientific advancements and market readiness, often pushing the envelope before a paradigm shift fully takes hold. This underscores the critical need for strategic foresight and robust support systems to bridge the divide and facilitate smoother transitions from innovative discovery to mainstream application.

STORYTELLING AS A TOOL FOR ENGAGEMENT

This brings us to storytelling. Steve Jobs was celebrated not only for his visionary approach to technology but also for his exceptional storytelling abilities. Many have noted that Jobs' storytelling was a key element of his success, turning complex technology into accessible and emotionally engaging stories that helped define Apple's identity.

Storytelling can be a powerful tool that helps make sense of these complicated and conflicted realities, but it is often underused. The effectiveness of storytelling is not just anecdotal; it is backed by substantial scientific evidence from various fields: from neuroscience to cognitive psychology.

First, storytelling helps in framing anomalies in a positive light, making them more palatable and even desirable to investors and collaborators. The same is true for failures. Take, for instance, the discovery of penicillin. What is now considered a great discovery that revolutionized medicine was actually a somewhat failed experiment that resulted in a mold (penicillium notatum) in petri dishes. Alexander Fleming observed that the bacteria surrounding the mold had died. Despite this significant finding, penicillin was not commercially produced until World War II due to the lack of a procedure for its mass development and other obstacles that are all too well known to anyone trying to bring something from the lab to the market. No doubt that the immense need arising from war casualties incentivized and sped up its production.

THE UNEXPECTED PATHS TO SUCCESS

Another famous example is Viagra, one of the most influential and controversial drugs of the last 30 years. Initially, one of the main ingredients was developed to treat heart conditions. However, what was first observed as an unpredicted side effect turned out to be a blockbuster drug. Both cases showcase that embracing and reframing the unexpected can lead to significant success. Stumbling upon unexpected breakthroughs or pivoting from initial failures can ultimately lead to significant advancement.

The cases also show the importance of foresight in tech transfer, particularly in recognizing when an anomaly could lead to a paradigm shift. While researchers are easily trapped inside „normal science," technology transfer professionals need to practice staying ahead of these shifts.

Cultivating Innovation: Researchers, Students, and Industry Unite for Collaborative Growth at a tomato producer Paradajz. Source: Uniminds.si.

THE EMOTIONAL IMPACT OF STORYTELLING

Secondly, neuroscience has shown that our brains are wired to respond to stories. When we hear a story, our brains release oxytocin, a hormone associated with empathy and emotional connection. This makes stories not just memorable but also emotionally engaging. According to research by Paul Zak, a professor of economics, psychology, and management, oxytocin is produced when we are trusted or shown kindness, and it motivates cooperation with others. Stories that build emotional and empathetic connections can significantly enhance the engagement and recall of information (Zak, 2015).

Furthermore, cognitive psychology supports the idea that narratives are an automatic way for humans to organize and understand information. Jerome Bruner, a cognitive psychologist, argues that humans think, perceive, and remember in terms of narratives (Bruner, 1986). Stories can significantly enhance the understanding and retention of complex information by structuring it in a way that aligns with how our brains naturally process experiences and knowledge (Dudley et al., 2023). This makes storytelling especially useful for technology transfer, which has proven to be difficult to understand both in terms of technologies and the process itself.

THE IMPORTANCE OF FIRST IMPRESSIONS

In the dynamic realm of technology transfer, the first impression often makes or breaks the opportunity for a successful collaboration. Yet, many presentations within this field fall into the trap of being monotonous and uninspiring, failing to captivate or persuade their audience. This lackluster delivery can turn a potentially groundbreaking idea into a missed opportunity, as it may not engage the crucial stakeholders who could drive the technology forward. A tech transfer officer's role is not merely administrative but also deeply strategic; they must possess the keen eye of a diamond appraiser, recognizing and nurturing the raw potential in ideas before they are polished into their final form. Effective presentations are essential in this process, serving as the first crucial link in a chain that can lead to successful commercialization and innovation. By mastering the art of storytelling and presentation, tech transfer officers can ensure that promising ideas are understood and accepted.

Thirdly, the business world has long recognized the value of storytelling, emphasizing that storytelling is not just for marketing but should be cultivated throughout organizations to improve engagement and influence. It is widely accepted that it adds value to business across different specters, from increasing brand recognition to managing change in the company. It is particularly present in the startup world, where it has become almost synonymous with recruitment, funding, and sales processes, and

founders use it almost routinely when "pitching" (Mills, 2022). Research into the use of storytelling in business confirms that stories are crucial for both internal (employees) and external (customers) engagement. Stories help convey complex ideas in a relatable way, making them an effective tool for change management and innovation (Kemp et al., 2023). Startup founders dedicate a significant amount of their time to innovation storytelling (Taylor et al., 2023) Research has also established that storytelling is crucial for innovations to succeed, yet innovators (especially outside businesses) are not efficient in using it (Taylor et al., 2023).

BRIDGING THE GAP

The implications of these findings are profound for technology transfer. By incorporating storytelling into technology transfer strategies, we can bridge the gap between the lab and the market more effectively. Stories can help potential partners, investors, and customers understand the significance and potential impact of new technologies even in the anomalies phase, before the paradigm shift. This narrative approach can make complex and technical information more accessible, engaging, and persuasive, and it also helps us understand our own processes better.

Innovators and technology transfer professionals must thus not only recognize the potential of the new technology but, more importantly, have the vision and strategic insight to contribute to the conditions that will allow the technology to redefine the market and/or industry. In this light, technology transfer professionals become more than mere facilitators. They become key players, guiding and shaping innovation to the point where it can spark significant change. But, more importantly, their role is much more complicated than what it appears to be at first glance, just like the process itself.

CONNECTING THE DOTS IN STORYTELLING

Whether serendipitously, or by forgetting to reference Kierkegaard, Jobs also said, reflecting on how seemingly disconnected events of his life were essential to his later success: „You can't connect the dots looking forward; you can only connect them looking backwards. So you have to trust that the dots will somehow connect in your future." Indeed, storytelling helps frame failures and anomalies in a positive light, making them more palatable and even desirable to investors and collaborators.

In summary, storytelling is more than a communication technique; it is a scientifically supported method that leverages the natural tendencies of the human brain to enhance understanding, retention, and emotional connection. In the context of technology transfer, storytelling can transform how innovations are perceived and adopted, making it an indispensable tool for navigating the complexities of bringing new technologies to market. The personal narrative detail that is often at the heart of a good story is one of the most powerful forms of communication that exists. Several experts, and indeed scientists themselves, agree that we live in a time where it is crucial that scientists take an active role in communicating with the public about what and why they do and how this matters (Suzuki et al., 2018).

Therefore, technology transfer should use storytelling intentionally. It should capitalize on suspense, on failures, and cliffhangers. This demands a certain kind of personality traits of the tech transfer officer, more than just the right mixture of technical knowledge and business savvy. This person must weave together the threads of innovation, failure, and coincidences into a compelling narrative that captures the imagination of potential partners, investors, and markets, always one step ahead, already stepping forward while making sense for everybody else backwards. Tech transfer requires the heart of a storyteller, envisioning not just what a technology is but what it could become. By imagining and telling this story to oneself and to others, we bridge the gap between invention and impact, turning raw potential into a shared vision of the future.

THE IMPORTANCE OF COMMUNITY

This kind of foresight is impossible without community. Storytelling lies at the heart of community building because it fosters shared understanding and collective identity. In Slovenia, this is exemplified in a government initiative that connects all technology transfer offices of public research institutions in two consortia. Such an approach not only facilitates the exchange of resources and expertise but also addresses the gaps left by the traditional linear models of tech transfer. This network is instrumental in enhancing the skills of tech transfer professionals, particularly in the realms of resilience, adaptability, and narrative construction. As we navigate the intricacies of technology transfer, it becomes evident that mastering the art of storytelling is crucial. Effective storytelling can transform the perception of failure into a narrative of growth and can help us create the vision required for this profession. This essay, with its own narrative shortcomings, underscores the point—perhaps not the finest example of storytelling itself, the lack of it actually serves as a heightened argument for the need for further training in this essential skill.

REFERENCES

Azagra-Caro, J., Fernández-Mesa, A., & Robinson-Garcia, N. (2020). 'Getting out of the closet': Scientific authorship of literary fiction and knowledge transfer. *The Journal of Technology Transfer*, 45, doi: 10.1007/s10961-018-9672-6.

Bruner, J. (1986). *Actual Minds, Possible Worlds*. Harvard University Press.

Chesbrough, H. (2003). Open Innovation: The New Imperative for Creating and Profiting from Technology. Harvard Business School Press.

Dudley, M. Z., Squires, G. K., Petroske, T. M., Dawson, S., & Brewer, J. (2023). The use of narrative in science and health communication: A scoping review. *Patient Education and Counseling, 112*, Article 107752. doi: 10.1016/j.pec.2023.107752.

Isaacson, W. (2011). *Steve Jobs*. Simon & Schuster.

Kemp, A., Gravois, R., Syrdal, H., & McDougal, E. (2023). Storytelling is not just for marketing: Cultivating a storytelling culture throughout the organization. *Business Horizons, 66*(3), 313-324. doi: 10.1016/j.bushor.2023.01.001.

Kuhn, T.S. (1962). *The Structure of Scientific Revolutions*. University of Chicago Press.

Link, A. N., Siegel, D. S., & Bozeman, B. (2007). An empirical analysis of the propensity of academics to engage in informal university technology transfer. Industrial and Corporate Change, 16(4), 641–655. doi: 10.1093/icc/dtm020.

Mills, A., & Key, T.M. (2022). Strategic storytelling. *Business Horizons*, 65(3), 309-318. doi: 10.1016/j.bushor.2022.01.005.

Rogers, E.M. (2002). Diffusion of Innovations. Free Press.doi: 10.4324/9780203710753-35.

Sweetman, A. K., Smith, A. J., De Jonge, D. S. W., Hahn, T., Schroedl, P., Silverstein, M., Andrade, C., Edwards, R. L., Lough, A. J. M., Woulds, C., Homoky, W. B., Koschinsky, A., Fuchs, S., Kuhn, T., Geiger, F., & Marlow, J. J. (2024). Evidence of dark oxygen production at the abyssal seafloor. *Nature Geoscience, 17*(8), 737–739. https://doi.org/10.1038/s41561-024-01480-8.

Taylor, K.T., Taylor, S., Greulich, K., Singleton, M., O'Shea,, C., & Surrao, A. (2023). The Impact of Storytelling on Innovation Success. *Research-Technology Management, 66*, 17 - 27. doi: 10.1080/08956308.2023.2212567.

Teece, D. J. (2010). Business models, business strategy and innovation. *Long Range Planning, 43*(2–3), 172–194. doi: 10.1016/j.lrp.2009.07.003.

Zak P. J. (2015). Why inspiring stories make us react: the neuroscience of narrative. *Cerebrum : the Dana forum on brain science*, 2015.

Author:
Polona Juvančič