

DIFFERENT LEVELS OF KNOWLEDGE TRANSFER IN BUILDING A GLOBALLY COMPETITIVE TECHNOLOGY TRANSFER NETWORK

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Abstract: *The University Technology Enterprise Network (UTEN), which was launched in March 2007, includes 15 Portuguese Universities and select international partners in a 5-Year program funded by the Portuguese government. Participants in this program included, The Innovation, Creativity, Capital (IC²) Institute at The University of Texas at Austin, The Portuguese National Science Foundation (FCT), Portuguese Technology Transfer Officers (TTOs), and select international partners. The main objective is to accelerate the development of a sustainable, globally competitive, professional technology transfer and commercialization network within Portugal to increase Portugal's international competitiveness in university-based science and technology transfer and commercialization. To study and explicate key knowledge transfer issues of this project, we use the Knowledge Spiral Model (Nonaka and Takeouchi, 1995) which is based on the distinction between tacit and explicit knowledge theory developed by Polanyi (1966). Within the Knowledge Spiral Model there are four types of knowledge transformation: 1) Socialization: From tacit to tacit. 2) Externalization: From tacit to explicit. 3) Combination: From explicit to explicit. 4) Internalization: From explicit to tacit. In the UTEN Program, there are specific set of activities and programs related to each of the Knowledge Spiral's Model four groups of knowledge transformation. These UTEN activities include: International Workshops, Training Weeks, On-the-Job-Training, International Internships, and In-Situ (In-Situation) Training.*

Keywords: *Marketing and technology transfer / Knowledge spiralmodel / Knowledge.*

DIFERENTES ASPECTOS DE LA TRANSFERENCIA DE TECNOLOGÍA: CONSTRUYENDO UNA RED DE TRANSFERENCIA DE TECNOLOGÍA COMPETITIVA A NIVEL GLOBAL

Resumen: *La Red de Empresas Tecnológicas de la Universidad (UTEN), que fue creada en marzo del año 2007, incluye quince universidades portuguesas y selecciona socios internacionales en un programa de cinco años de duración que es financiado por el Gobierno portugués. Participan en este programa el Instituto IC² (Innovación, Creatividad y Capital) de la Universidad de Texas en Austin, la Fundación Nacional de Ciencia de Portugal (FCT), los agentes de transferencia de tecnología de Portugal (OTRI) y algunos socios internacionales. El objetivo principal es acelerar el desarrollo de una red de comercialización y transferencia de tecnología profesional que sea sostenible y competitiva globalmente. Dentro de Portugal, aumenta su competitividad internacional en ciencia de base universitaria y en la comercialización y transferencia de tecnología. Para estudiar y explicar las principales cuestiones de transferencia de conocimientos de este proyecto se utiliza el "modelo espiral de conocimiento" (Nonaka y Takeouchi, 1995), que se basa en la distinción entre la teoría del conocimiento tácito y explícito desarrollado por Polanyi (1966). Dentro del modelo espiral de conocimiento hay cuatro tipos de transformación de conocimiento: 1) socialización: de tácito a tácito; 2) externalización: de tácito a explícito; 3) combinación: de explícito a explícito; 4) internalización: de explícito a tácito. Dentro del programa de la UTEN hay actividades y programas que relacionamos con los cuatro grupos de transformación del conocimiento del modelo espiral de conocimiento. Las actividades de la UTEN incluyen talleres internacionales, semanas de formación, formación en el empleo, prácticas internacionales y formación "in-sit".*

Palabras clave: *Comercialización y transferencia de tecnología / Modelo espiral de conocimiento / Conocimiento.*

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1. CONCEPTUAL AND THEORETICAL BACKGROUND

1.1. INTRODUCTION

The Portuguese Science and Technology Foundation (FCT) launched The University Technology Enterprise Network (UTEN) with the IC² Institute, The University of Texas at Austin, in March 2007. UTEN's main objective was, and continues to be, to build, within five years, a globally competitive and sustainable science and technology (S&T) transfer and commercialization network managed by highly trained Portuguese professionals. To achieve this objective, UTEN programs and activities have focused on the development of skills and professional competence of Portuguese university technology transfer officers and managers through networking and training, on-the-job mentoring, and international internships and partnerships. At the core of the UTEN program is the objective of enhanced efficiency and effectiveness in technology transfer and commercialization for international markets.

1.2. TECHNOLOGY AS A KNOWLEDGE PHENOMENON

Technology is defined here as “the system that provides knowing and artifacts (arts/tools) needed for a production or an action”. Based on this definition, technology has two main aspects: Knowing (knowledge, information, and software) and Artifact (tool, equipment, and hardware). The emphasis of most technology studies or policies has often been on the artifact aspects of technology. This document emphasizes the knowing aspects of technology.

Technology transfer and commercialization is the set of processes that takes knowledge generated in the research labs of universities through the processes of science and technology application and commercialization.

1.3. THE NATURE OF KNOWLEDGE

How we perceive knowledge has deep impact on what we consider as technology. The study of knowledge and its nature has been a central subject matter of philosophy and epistemology since the Greek period, as “justified true belief,” a concept first introduced by Plato. Most recently (since the 1990s), the nature of knowledge has begun to attract a new wave of attention in terms of enhanced competitiveness and the creation of wealth and high value jobs. The strategic and resource roles of knowledge have been reviewed in the academic literature on “resource-based” and “knowledge-based” strategies (Penrose, 1959; Wernerfelt, 1984; Itami, 1987; Prahalad, 1990; Stalk, 1992; Leonard-Barton, 1992; Nonaka, 1995; Grant, 1996; Conner, 1996; Teece, 1997; Zack, 1998; von Krogh, 2000, p. 74). In addition to the academicians, practitioners and consultants have also contributed to the practical aspects of knowledge strategy (Allee, 1997; Amidon, 1997).

The following set of descriptions provides an overview of the variety and scope of perspectives for defining knowledge.

- 1) Knowledge is the resource of production (Drucker, 1993); Knowledge as a form of capital (Zeleny, 1989); and Knowledge as an element of production as implied in the industrial engineering definition.
- 2) Knowledge is a capacity to act (Sveiby, 1997); knowledge as a capacity for action (Stehr, 1996); and knowledge as an activity (Polanyi, 1966).
- 3) Hierarchy and depth of knowledge as structured into data, information, knowledge and wisdom. This hierarchy has a number of variations and is referred to in numerous sources (Amidon, 1997; Saint-Onge, 1997).
- 4) Knowledge as an entity, concept or phenomenon comparable with material and energy (Morin, 1992; Stonier, 1992).
- 5) Tacit and explicit knowledge (Polanyi, 1966; Leonard and Swap, 2005).
- 6) Knowledge as a dynamic human process of justifying personal belief toward the “truth” as considered by Nonaka and Takeuchi (1995).

The variety and the differences between the above definitions or descriptions of knowledge not only reflect the perspectives of different authors, but also the fields or disciplines of application they target. For instance the first and second definitions of knowledge are mostly related to the financial and economic viewpoints. The third definition has long served in information technology studies. The fourth definition is related to methodology and engineering. The fifth and sixth definitions concern learning organizations.

1.4. THE LEARNING ORGANIZATION

The basic thrust of the idea of the learning organization is to integrate knowledge that resides in human personnel with the administrative aspects of a business. Ikijurio Nonaka is the most prominent exponent of this view, and his book *The Knowledge Creating Company* (Nonaka, 1995) is one of the most cited and respected sources, also see Nonaka (1991).

Nonaka (1995) views knowledge as the basic unit of analysis for explaining the firms behavior, and its core features are: 1) an emphasis on knowledge creation, 2) a vivid distinction between “explicit knowledge” (like information) and “tacit knowledge,” and 3) the role of non-Cartesian epistemologies for further development of tacit knowledge. Nonaka’s distinction between tacit and explicit knowledge is based in turn on ideas of Michael Polanyi (1966), who stated the truism that “We know more than we can tell,” as a way to emphasize the nature of tacit knowledge. In his own rendering of these two categories Nonaka (1995) asserts that: “*explicit knowledge can be articulated in formal language including grammatical statements, mathematical expression, specifications, manuals, and so forth. This kind of knowledge thus can be transmitted across individuals formally and easily.*”

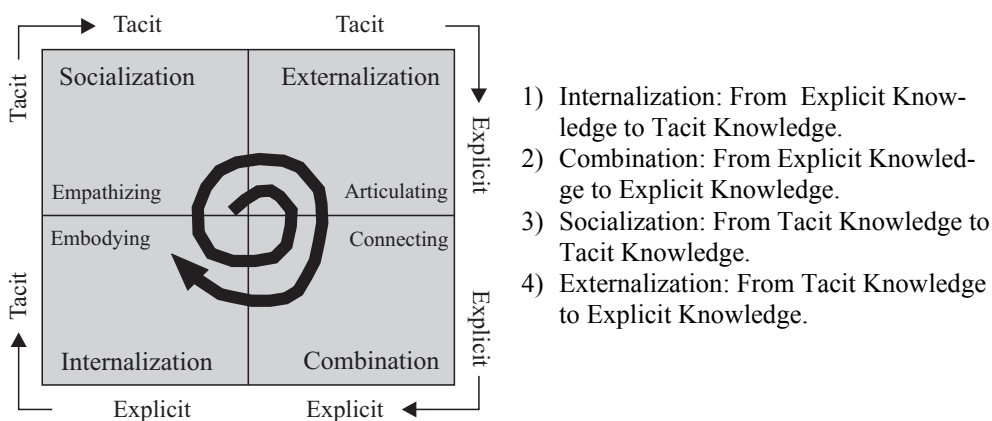
Tacit knowledge is hard to articulate with formal language. It is personal knowledge embedded in individual experience and involves intangible factors such as personal belief, perspective, and the value system. It is highly personal. It is hard to formalize and, therefore, difficult to communicate to others. Tacit knowledge is also deeply rooted in action and an individual commitment to a specific context - a craft or profession, a particular technology, or team”.

Although Nonaka bases his approach to knowledge on Polanyi’s work, he appreciatively also makes reference to the writings of Drucker (1993), Toffler (1990), Reich (1991) and Quinn (1992) as the authors who have initiated pioneering studies on the role, behavior and importance of knowledge in business. In short, Nonaka believes that the knowledge basic to the learning organization does not consist only of that which is formally and explicitly available in the information systems to which a firm has access, but also includes the knowledge held tacitly by a firm’s personnel, especially that which is central to skills of all kinds. Only where an organization takes steps to tap both kinds of knowledge will it fully embark into the realm of a learning organization.

1.5. KNOWLEDGE SPIRAL MODEL

The most important application that Nonaka makes of the distinction between tacit and explicit knowledge is to show the interrelations between the two kinds of knowledge in a firm’s activity of creating new knowledge. In his concept of Knowledge Spiral Model Nonaka posits four interactions that lay at the heart of the process. These interactions are conceptualized as a two-by-two matrix – knowledge moving from tacit to tacit (Socialization,) from explicit to explicit (Combination,) from tacit to explicit (Externalization) and from explicit to tacit (Internalization), Diagram 1.

Diagram 1.- The Knowledge Spiral Model



2. UTEN INTRODUCTION

UTEN (The University Technology Enterprise Network) has worked to (1) transfer technology transfer knowledge and practice to Portuguese technology transfer officers, and (2) to build sustainable partnerships and networks among technology transfer and commercialization experts and centers within Portugal (UTEN Portugal) and internationally to:

- Strengthen Portuguese industry-science relations, intellectual property management, and technology transfer and commercialization competence for international markets
- Deepen Portuguese understanding of the challenges and opportunities of university-based technology transfer and commercialization nationally and globally
- Learn and benefit from national and international experience and case studies on how to successfully promote regionally based, globally networked technology development and commercialization
- Foster entrepreneurial vision and competence in Portuguese academia and business as well as civic organizations
- Provide productive and sustainable international networking opportunities for Portuguese technology transfer managers and staff and for technology-based companies and start-ups

3. UTEN PROGRAMS: TRANSFORMATION OF EXPLICIT KNOWLEDGE TO EXPLICIT KNOWLEDGE

UTEN organized national and regional training workshops and conferences are designed to enhance technology transfer and commercialization awareness and know-how by:

- a) Deepening Portugal's understanding of science and technology transfer and commercialization through case studies and building on the experience of leading institutions worldwide.
- b) Fostering working relationships, sharing tools and perspectives, and drilling down to key challenges and issues facing Portuguese stakeholders.
- c) Building sustainable, critical mass of professional technology transfer talent to facilitate and support globally competitive technology commercialization.
- d) Establishing continuity in activities ranging from workshops to on-the-job training and internships to provide key mechanisms for successful technology commercialization.

As part of the UTEN program a series of programs for “opportunity recognition” were offered. Opportunity recognition programs intend to forecast the rela-

tionships between technology and market for a new business idea. Opportunity recognition programs were presented in a series of workshops and methodologies.

3.1. ON-THE-JOB TRAINING

UTEN Austin provided science and technology assessment and business development training for technology transfer managers, staff, and university researchers focused on assessing the business potential of science and technology from Portuguese institutions for international markets. Technology Portfolio and Assessment Training: Technology portfolio and assessment training focused on Portuguese technology transfer offices and researchers assessing the business potential of Portuguese science and technology in international markets as well as on identifying and securing international lead collaborators (e.g., entrepreneurs, research partners).

Rapid-Screen is a procedure for screening technology portfolios, with a focus on 4 to 8 hours of assessment (Zintgraff, 2010). The goal is to rapidly assess the application potential of a new business idea from market factors and the readiness of inventors and technology transfer offices. UTEN Austin worked jointly with Portuguese technology transfer offices to perform this procedure with the goal of transferring these assessment methodologies to the Portuguese Technology Transfer Officers (TTOs).

A more extensive *Market-Look* procedure explores, in-depth, the voice of the market regarding a new technology. This procedure consists of conducting 8 to 12 interviews with technology and market experts, potential customers and end users, and potential partners. Coaching and mentoring sessions were held with UTEN Austin personnel to transfer knowledge and practice to the Portuguese participants and assist the Portuguese TTOs and entrepreneurs.

UTEN Austin staff worked with Portuguese technology transfer offices in conducting in-depth international market assessments of select Portuguese technologies. A typical Market-Look strategy for enhanced international technology and market assessment training involved a team of at least members: the Portuguese researcher(s) and their technology transfer office, UTEN Austin technology transfer mentor(s), and US technical experts with strong business ties in the targeted technology space.

Assessments of Portuguese science and technology are increasing in number as Portuguese technology transfer offices conduct these assessments using their own staff. An emerging extra benefit of these increasing assessments is that Portuguese technology transfer offices are building regional databases and potentially a national database of Portuguese science and technology that can be accessed and assessed using standardized methodologies.

3.2. MOVING FROM EXPLICIT TO TACIT EXCHANGE

With both the rapid Screen and Market Look methodologies, UTEN training efforts consisted of three phases of enhanced learning moving from explicit to tacit exchange of knowledge:

- 1st phase: UTEN Austin and Portuguese technology transfer offices jointly performed science and technology portfolio and market assessments with a focus on international commercialization practice.
- 2nd phase: Portuguese technology transfer offices led technology portfolio and market assessments, and international commercialization assessments, with UTEN Austin observing and mentoring.
- 3rd phase: Portuguese technology transfer offices conducted technology portfolio and market assessments and international commercialization assessments, with UTEN Austin coaching and monitoring as needed, thereby emphasizing self-sufficiency.

4. INTERNALIZATION PROGRAMS: TRANSFORMATION OF EXPLICIT KNOWLEDGE TO TACIT KNOWLEDGE

Since the start of the UTEN program in 2007, a key strategy has been the building of UTEN participant organizations and the delivery of training using “living cases.” This approach had numerous advantages as it exposed UTEN Austin staff to real cases to learn key issues and challenges faced by Portuguese technology transfer offices. For Portuguese TTOs it contextualized learning and work results that not only trained, but also contributed directly to TTO productivity. The use of living cases was a strategic tool that helped UTEN Austin begin the training process at a grass roots level by helping to build positive relationships and trust with technology transfer offices that had the interest and capability to benefit from and help shape UTEN efforts. It also demonstrated to Portuguese partners UTEN’s interest in going beyond generic training and toward the larger goal of making a real impact on technology transfer and international commercialization activities.

Technology Transfer Training Workshops: Two week technology transfer training workshops were held at the IC² Institute at The University of Texas at Austin to provide an overview of science and technology commercialization perspectives and practices of several Texas-based entities, real-time training, and an opportunity for the Portuguese TT managers and staff to interact and learn from each other for two-weeks of intense study, practice, and mutual awareness building, thereby strengthening the Portuguese national technology transfer network. Eight primary topics were addressed:

- Licensing, negotiations, and closing the deal.
- Formation, launch, and growth of university spin-outs.
- Technology development and licensing to meet the needs of industry.
- Running a technology transfer office to maximize technology commercialization.
- Marketing skills for technology transfer managers.
- Entrepreneurial skills for technology transfer managers.
- Technology screening and market validation methodologies.
- How to foster and develop effective business incubation.

Attendees emphasized key skills, techniques, and ideas that they learned such as negotiation and licensing skills, techniques for technology evaluation, marketing plans for technology transfer offices, benchmarking, and useful suggestions about operational procedures. The two-week workshops provided hands-on training and mentoring for each attendee.

5. SOCIALIZATION PROGRAMS: TRANSFORMATION OF FROM TACIT KNOWLEDGE TO TACIT KNOWLEDGE.

5.1. INTERNATIONAL INTERNSHIPS

During the UTEN program or training, Portuguese technology transfer officers and managers were encouraged to submit applications to be considered for FCT-sponsored UTEN training and internships with international hosts. The objectives of the training and internships were to:

- 1) Encourage Portuguese technology transfer and commercialization managers and staff to participate in in-depth, hands-on international training to increase their professional competence.
- 2) Build a globally competitive and sustainable science and technology commercialization network in Portugal.

During the past three years, competitively selected interns were placed by UTEN Austin with three Texas-based institutions: The Office of Technology Commercialization at The University of Texas at Austin, the Office of Technology Commercialization at Texas A&M University; and South Texas Technology Management (STTM) in San Antonio. The objective was to provide an opportunity for cooperative work with the host institution and on-the-job learning with the potential of fostering long-term partnerships. All interns brought to their internship a portfolio of Portuguese technologies to evaluate and consider for international research and commercial development.

5.2. IN-SITU MENTORING

In-Situ (In-Situation) mentoring focuses on developing and deploying customized tools and processes enabling more efficient technology transfer in conjunction with Portugal's Technology transfer Offices (TTOs). Processes deployed built on learning from previous UTEN mentoring, internships, and training activities. During the In-Situ engagement, a UTEN Austin expert worked with TTO staff on location for six days to prototype and develop enhanced internal technology transfer processes given the institutional and regional situational realities of Tec-Minho.

In-Situ mentoring focuses on completing the transfer of UTEN technology transfer and commercialization know-how and network building to select Portuguese technology transfer offices so that they can more effectively and efficiently manage technology transfer projects, practices, and strategies. Select Portuguese technology transfer offices host a UTEN Austin expert to work hands-on with the Portuguese technology transfer staff according to an agreed-upon plan. In-Situ mentoring allows UTEN experts to better understand the particular challenges and strengths of the select Portuguese technology transfer offices and to customize particular training topics to specific management needs. The goal is to facilitate the more complete transfer of expert knowledge and implementation issues including technology transfer organization design, human resource and technology transfer project management, portfolio assessment and management, and the effectiveness of different technology transfer strategies and international market assessments within the context of the technology transfer office's unique institutional and regional circumstances.

During the In-Situ Training, Portuguese technology transfer office staff members are strongly encouraged to work with and lead UTEN staff in the development of technology assessments in an effort to better transfer assessment methodologies. In order to better meet follow-on commercialization expectations of client entrepreneurs and technologists, and to maximize training benefits and international networking opportunities, it is necessary for there to be increased follow-on and highly selective market development activities and training to be transferred.

6. CONCLUSION

The UTEN program includes all aspects of the Knowledge Spiral Model to enhance the knowledge capabilities of the participants in the programs for Technology Transfer Officers (TTOs) of Portuguese universities.

We have observed that the Combination way of knowledge transformation which is about transfer of Explicit (Codified) Knowledge to Explicit Knowledge is the most cost effective for reaching a large audience. In this group of knowledge transformation the Portuguese TTOs had access to the same documents that are

used by offices of technology transfer at major Texas universities including manuals and procedures.

The Socialization of knowledge transformation, which is polar to Combination, is about transfer of tacit to tacit knowledge. This is often the deepest level of learning and the most expensive way for knowledge transfer. This way requires heavy time commitment focuses on a select “students.” The UTEN program included internship programs and In-Situ Training for this group.

Externalization, which is from tacit knowledge to explicit knowledge, is the most difficult. Externalization, which is central to tapping the enormous amount of hidden knowledge a firm has, often requires the development of new outlooks or even methodologies.

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