Collaboration and the Knowledge Economy: Issues, Applications, Case Studies
Paul Cunningham and Miriam Cunningham (Eds)
IOS Press, 2008 Amsterdam
ISBN 978–1–58603–924-0

Knowledge Circulation in ICT the Virtue of Practice-oriented Research

Henk DE POOT, Annemiek VAN DER KOLK
Telematica Instituut, Brouwerijstraat 1, Enschede, 7523 XC, Netherlands
Tel: +31 53 4850485, Fax: + 31 53 4850400
Email: Henk.dePoot@telin.nl, Annemiek.vanderKolk@telin.nl

Abstract: Since 2005 the Dutch Ministry of Education has funded regional programmes to stimulate knowledge circulation by Dutch Universities of Applied Science in consortia with small and medium enterprises and communities of professionals from public organizations. In the first 3 years, a striking 45 (34%) of the granted proposals addressed ICT as a main topic on their innovation agenda. Here we investigate the nature of these ICT innovation programmes which rest on a solid basis of multidisciplinary knowledge input from the side of professors and the active participation in knowledge creation from practitioners in the field.

Keywords: ICT, Innovation, SME, Knowledge Circulation, Communities of Practice, Living Labs

1. Regional Attention and Action for Knowledge Circulation

Since 2005 the Dutch Ministry of Education, Culture and Science has funded some 200 "RAAK" regional innovation programmes where Universities of Applied Science (UAS, a.k.a. polytechnic colleges) collaborate in networks with regional partners.

RAAK's goal is to enable practice-oriented research at UASs as well as stimulate the regional network of small and medium enterprises (SMEs) and public institutions in their eco-system. The scheme compares, a.o., to EU's CRAFT, STREPs and Collective Research schemes, the Swiss CTI, the German FH3, the Finnish Tekes and the Romanian ReNITT.

RAAK is an acronym for Regional Attention and Action for Knowledge circulation. Partners in RAAK can be consortia of SMEs as well as professionals from public organizations. The Foundation Innovation Alliance (SIA) manages the RAAK-scheme. SMEs and professionals articulate the research agenda and the collaborative research setting enables a knowledge flow from UASs to practitioners and back [1]. A joint responsibility is essential, as UASs educate the future managers, specialists, and professionals in many SMEs and public institutions. In this paper we look into the large proportion of ICT-related innovation questions that have as yet been articulated.

Some of the topics of the European eCompetences Framework and numerous national ICT research subsidies are prominent in RAAK as well. Yet the scheme fulfils a complementary role to the other innovation grants as our survey among participating SMEs shows. 52,6% of the respondents (N=806) indicated they had not used other innovation grants in the three preceding years. 19,2% used an investigation grant for product development, 8,6% used the Innovation voucher for one-on-one consultancy, 6,7% used EU grants and 8,2% mentioned other grants from regional and national government.

Another aspect of the RAAK subsidy is that the network of participating companies and/or professionals is sufficiently large to bring knowledge circulation about. Depending on the amount of subsidy (typically covering the cost of 1 or more FTEs of research capacity) between 5 and 15 SMEs or some twenty professionals are required upfront. For subsidies amounting to 4 or 5 FTEs the network of SMEs and/or professionals must grow to

40-50 participants. This stimulates partners to address a sufficiently generic innovation agenda. If only one partner signs up for an innovation challenge, that will not be a basis for a joint research programme. The innovation topics are left to the proposers.

2. ICT Ranks High on Innovation Agenda of SMEs and Professionals

Between 2005 and 2007, 240 RAAK innovation programmes have been proposed of which 149 have been granted. A striking 45 (34%) of these granted proposals include ICT as a main topic on their innovation agenda, even though the RAAK subsidy does not demand that innovations be ICT-based at all. In fact any innovation, whether social, organizational, methodological or technological is equally admissible.

2.1 Why Does ICT Dominate the Innovation Agenda So Strongly?

The prominence of ICT on the innovation agenda might just be that it percolates into all these different domains. As an innovation motor ICT is closely connected to innovation trends: As much as innovation trends are inspired by the possibilities of ICT, ICT developments stem from the societal and economic needs for information and communication. Improved transparency of working, extensive information logistics, tightly coupled activities of business partners or social partners, and intensified communication across a wide range of domains have been identified in innovation agendas since the early 1980s [2, 3]. Notwithstanding this, it often takes decades before visions for business process improvement are implemented. Quite often, ICT is part of these innovation plans.

This raises several questions:

- What ICT innovations are most prominent for SME and professionals?
- Which public and private sectors are most involved in ICT innovation?
- What kind of knowledge circulation is most prominent among different programmes?
- What lessons can be learned from conducting these innovation programmes?

These questions will be addressed in the remainder of this paper.

3. Methodology Used

The technologies involved, the domain to which programme partners belong, and the methods of knowledge circulation are compared for the different programmes in order to answer these questions. For some of the programmes more information exists, because they have been followed start to end, whereas other programmes are still running at the moment of writing. The results are summarised in Tables 1 through 4, describing and showing the topics (Table 1), the application domains, nr of SMEs, participating professionals, and professors with theoretical and practical skills (Table 2), the innovation goals (Table 3), and ways in which a bidirectional knowledge flow or knowledge circulation is achieved (Table 4).

4. Comparison of Innovation Programmes

4.1 Prominent ICT Innovations

When ICT innovations of the 45 RAAK Programmes are classified according to technologies proposed, a large part of ICT innovations deal with applying or improving general end-user services for communication (18%), media delivery and gaming (18%).

Next come systems integration solutions applying logistics (18%), sensors (15%), and human interaction in smart solutions such as domotics (7%), location-based services (7%) or solutions targeted to a specific group (4%).

Finally development of software (9%) and hardware (4%) play a role to develop new building bricks and new engineering principles. Table 1 shows examples of the respective topics addressed.

Table 1: Main Topics Addressed in RAAK ICT Innovation Programmes Granted Between 2005 and 2007

Communication (18%)	Media & Gaming (18%)
• distance learning • open cultural collaboration • online training and health log • monitoring based e-care concepts • transparent care solutions • networked healthcare • patient-oriented working • games enticing communication in care	• cross media format development • cross media business network • digital cultural heritage • media literacy • augmented reality (AR) for design & architecture • game and interaction design • artists in media industries
Human Interaction (18%)	**Logistics (18%)**
• e-business portal for SME • speech therapy portal for professionals • cognitive support for dementia patients • location-based wireless services • location-based tourist services	• logistics and process laboratory • agri-chain logistics information • air cargo/sea freight logistics • business and manufacturing logistics • consented homecare planning
Sensors (15%)	**Hardware and Software (13%)**
• synthetic insects with embedded sensors • sensing crop growing operations • computer vision-based expertise • computer vision-based microbial analysis • water quality sensing systems	• polymer electronics • embedded Linux • performance management systems • technology-based care concepts • high tech orthopaedics

In Table 1 human centred ICT topics make up 54%, and applied ICT solutions account even for 87%. Even on this limited sample size this teaches us something about the nature of SME-based ICT innovation, being primarily applied and more often than not human centred. Customers still count for SME whereas larger companies and organizations may address markets rather than individuals.

Also the prominence of logistics and sensors into integrated systems is remarkable. In their pioneering phase these technologies were out of reach of SME, but they are rapidly become more affordable and hence a business necessity.

4.2 Prominent Sectors Involved in ICT Innovation

When ICT innovations of the 45 RAAK programmes are classified according to the public and private sectors involved, the inclusion of target groups becomes evident. Table 2 shows the number of innovation programmes for each application domain. A distinction is made between programmes running, and programmes that have finalised. The information about finalised programmes is more complete. As can be seen the consortia grow in size and quality. The proportions of SMEs and professionals as primary target groups (between brackets are the absolute numbers) increase throughout the programmes.

Only among the agriculture and environment programmes, the proportions of SMEs and professionals do not further increase. But these consortia are already large from the start.
Two other phenomena in Table 2 deserve attention:

Table 2: Application Domains of RAAK ICT Innovation Programmes Granted Between 2005 and 2007

According to the Application Domains	Programmes		Nr. SMEs		Professionals		Professors
	Run-ning	fina-lised	run-ning	fina-lised	run-ning	fina-lised	Total
Human Centric Domains:	**12**	**8**	**29% (40)**	**52% (134)**	**57% (148)**	**71% (93)**	**36**
• Healthcare & Elderly Care	5	5	36% (21)	49% (87)	67% (83)	73% (58)	22
• Culture and Education	6	0	13% (7)	N/A	58% (65)	N/A	8
• Tourism and sports	1	3	44% (12)	60% (47)	0% (0)	67% (35)	6
Technology Centric Domains:	**7**	**18**	**66% (51)**	**77% (584)**	**36% (19)**	**59% (164)**	**40**
• Industry	3	10	75% (24)	78% (417)	32% (10)	53% (74)	23
• Business and transport	2	3	44% (8)	81% (128)	0% (0)	67% (39)	7
• Agriculture and environment	2	2	70% (19)	70% (56)	56% (9)	56% (20)	4
• Construction	0	3	N/A	73% (76)	N/A	66% (31)	6

Table 3: Examples of Plans in RAAK ICT Innovation Programmes Across Seven Application Domains

Industry • coping with chain dependency • mastering computer-aided manufacturing • acceleration through computer vision • joint product development • integrating products in end-to-end systems • innovation through creativity • future product paradigms • pilot cases to test new technologies	Care • communication platform • from products to systems to services • service prototypes, e.g. for telecare • 21st century hospital • pilots • ICT support for product evaluation • implementation teams
Culture and Education • e-inclusion of students • informal collaboration pilot • access to heritage collections • augmented reality as culture experience • media literacy embedded in curriculum • web-enabled assessment tools	Business and transport • e-business prototypes • changing rules of business • co-creation • implementation of protocols • value-added ICT utilisation
Tourism and Sports • e-coaching pilot experiment • location-based services • prototype tourist services • integration of hospitality services	Agriculture and environment • logistic readiness benchmark • GS1 conformance pilot • automated agricultural bookkeeping • sensor-enabled waste water control
	Construction • smart home demonstration • domotics system integration • augmented reality for visualisation

1. The proportion of SMEs (compared to other participating organisations) is highest in the technology-centric programmes, whereas the proportion of professionals (compared to other participating individuals in each innovation programme) is highest in human-centric programmes. Since 2006 this phenomenon was acknowledged by SIA for innovation programmes in general. When social innovation and human factors are heavily involved, professionals from public institutions should become innovation partners like SME entrepreneurs. In some sectors a public institution will invest in innovation, whereas in other sectors (e.g. tourism) private sector investments are key.
2. In the rightmost column the professors (in Dutch: "lectoren") associated with the respective innovation programmes are mentioned. These professors have been appointed at Dutch UASs since 2001 to stimulate multidisciplinary research and improve the collaboration between academia and practitioners [4]. They have a background in science and in the practice of their field of expertise. On average 1,6 professors are involved in the technology-centric innovation programmes, and 1,8 professors are involved in the human-centric innovation programmes. Healthcare and elderly care get most support with 2,2 professors participating on average.

Note that a large proportion of human-centric or end-user applications are found in the domains of healthcare (11%), elderly care (11%), tourism and sports (9%), culture (7%), and education (7%). On the other hand, many technology-centric ICT innovations are just components in larger systems in industry (24%), building & construction (7%), agriculture (7%), business (7%), process industry (4%), transport (4%), and environment (2%).
Together the human-centric domain accounts for 44% of the ICT innovations with a considerable involvement of the public sector, whereas the technology-centric domain seems to be governed by industry and other private sectors. The reason for these separate domains to stand out may be two faces of Baumol and Bowen's theorem [5]. In business, agriculture, and industry, efficiency can always be improved by technology, so this provides a breeding ground for high-tech ICT innovations. In the public sector, high touch is increasingly important. Therefore ICT in should improve rather than replace the human element in numerous services delivered there.

Table 3 shows examples of the respective areas addressed within each innovation domain. The programmes are different in their ambitions.

- The Industry programmes point at strategic questions and hard problems and ICT as an innovation in itself.
- The Business, Transport, and Agriculture programmes emphasize the added value of information logistics.
- The Culture, Education and Tourism programmes seem keenly aware that any service will only work when properly introduced and adopted by the targeted user group.
- The Healthcare programmes are focussed on efficiency through better communication even enabling forms of telecare.
- The construction programmes address new phenomena such as smart homes and augmented reality. To understand their virtues and pitfalls, they need to be explored.

4.3 Comparison of Knowledge Circulation Methods

A mere analysis of innovative ICT technologies and sectors and the ambitions discussed above already hints into what the knowledge circulation in the innovation programmes is about. With knowledge circulation residing in the title of the RAAK scheme, it needs to be properly planned in every innovation programme proposed.

Table 4 shows examples of knowledge circulation methods proposed in the respective programmes. Roughly they fall into five categories, Prototypes, Laboratories, Living Labs, Communication Platforms, and Communities of Practice. In the technology centric

programmes, the proposed knowledge circulation techniques, are prototypes (36%), laboratories (36%), and communities of practice (28%).

Table 4: Examples of Forms of Knowledge Circulation Implemented in RAAK ICT Innovation Programmes

Communities of practice: • …for technology-based care concepts • …for speech therapists • …for sea freight logistics • …for sensor technology for water systems • …for manufacturing logistics • …for performance management systems • …for high tech orthopaedics • cross media network • knowledge clusters for transparent care solutions • implementation teams for demand-driven homecare planning • e-business community for e-business consultancy	Living labs • laboratory for domotics for handicapped • living laboratory technology based care concepts • laboratory for AR design & architecture • living laboratory location-based wireless services • digital cultural heritage laboratory gaming and design career centre
Prototypes: • educative infrastructure for media literacy • service prototypes for ICT support for dementia patients • 21st century hospital for patient oriented working • integral design principles for domotics for the elderly • development of logistics standard for logistics chain information • value creating concepts for logistics chain information • prototype building for registering growing activities • cross-sectoral innovation by means of computer vision applications	Communication platforms: • platform for creative industries for artists in media industries • SportLog open source training log / performance monitor • electronic learning environment distance learning • platform for communication and gaming in care • solutions for healthcare at home / domotics in care • common showcase improving networked healthcare
	Laboratories: • polymer electronics laboratory • embedded electronics laboratory • computer vision expertise centre • embedded ICT products laboratory • logistics and process laboratory for testing industry principles

In contrast, the human-centric innovation programmes hinge much stronger on user involvement either as subjects in living labs (40%), or as users of a communication platform (30%), or as peers sharing experiences in a Community of Practice (15%). In the remaining 15% of the programmes a prototype is built to further the discussion on ICT themes in the organization.

So the object being shared in knowledge circulation differs significantly between ICT innovation programmes. In general human-centric ICT innovation programmes tend to involve more non-technical persons, whereas research and development staff are the main target group for the technology-centric ICT innovation. Also there is a difference in emphasis. There is a prototype implicit in every living lab setting, but a prototype does not necessarily involve a user test, let alone a living lab setting. So the technology centric innovations seem to dig deeper whereas the human centric innovations are breadth first.

5. Best Practices and Lessons Learned

As part of the RAAK monitoring activity participants share their best practices and lessons learned throughout the innovation programme. Many of these best practices are generic, in that they could be valid in other innovation programmes where educational institutes and practitioners collaborate. Some of the best practices and lessons learned were specific for ICT innovation however. We summarise them here.

5.1 Best Practices

- Make an explicit separation between the creative and the professional phase (when involving business partners).
- Tower of Babel: realise that disciplines speak different languages.
- Ease of use: Make quick reference guides to relieve users from thick manuals.
- Social pressure: Name and shame list for participants who do not participate.
- Heart of the matter: Involve entrepreneurs in usability laboratories. Make them realise what product or service usability is about.
- Complexity: Use pressure cooker innovation to kick-start the design of ICT services
- Complexity: Take the value chain into account (in domotics, healthcare, agriculture, logistics, business, tourism).
- Joint academic-applied laboratories open to UAS students and SMEs.
- Well-equipped laboratories to attract entrepreneurs, professionals as well as students.
- Use multiple perspectives, e.g. not just healthcare, but also business perspectives.

5.2 Lessons Learned: Threats and Weaknesses

- Divergence through technologies opportunities: Stay on focus.
- Rapid evolution of technology: danger of betting on the wrong horse.
- Confusion of demand-driven problems and problems chosen to train competences.
- Even in high-tech sectors such as installation technology, less than 5% of the workforce is innovation-minded. So a change of mindset must be achieved,

5.3 Lessons Learned: Strengths and Opportunities

- Developments toward digitisation open the hearts and minds for standardisation as well.
- Regional innovation partners can help one another get in touch with new business areas.
- Consider students as new-technology literates.
- Enabling technologies such as augmented reality, location-based services, computer vision, 3D gaming, and logistics all prove to be widely applicable in many areas.

6. Conclusions

6.1 Upfront User Involvement When Necessary

According to IDEO's maxim, failing faster to succeed sooner, upfront user involvement helps to identify system failures [6], but this happens at the expense of limited product development.

Ideally the prototypes for a successful user test are available when a programme starts. The settings that are implicit in public sector programmes encompass more social complexity, which needs to be tested, whereas the settings in private sector programmes allow more technical complexity. Yet, even there, widespread impact is inversely proportional to complexity, and only simple principles run a chance for reasonable adoption.

6.2 Laboratories as a Collaborative Investment

A large part of the ICT-innovation projects encompass setting up laboratories (for technology-centric innovation programmes) and living laboratories (for human-centric innovation programmes) both combined with communities of practice. Obviously the resources for SME and SME-sized public organizations to organise such ICT innovations on their own are only limited and collaboration with UASs, other knowledge institutes, and peers really provides a competitive edge.

6.3 The Virtue of Practice-Oriented Research in ICT-Education

On the one hand the idea to improve both education and practice through collaboration works well, given the many inspiring innovation programmes we have seen so far.

On the other hand, there is something about ICT education that seems to be lacking in general curricula: more often than not the technology comes to life in applications outside the core theoretical or technological domain.

If we want our ICT students to be well-prepared, the lessons learned, and best practices (such as living labs) promoted in the knowledge circulation projects discussed, cannot be left to the mere initiatives of individual teachers and professors in higher education. These aspects of social innovation need to be embedded in the general ICT curricula!

References

[1] van Vliet, Harry; Horvath, Janika. SMEs and innovation in the Netherlands: Spinning the wheel: knowledge circulation in (hydraulic) motion. *Industry and Higher Education*, Volume 18, Number 5, October 2004 , pp. 309-319(11)

[2] Wellborn, Stanley. A world of communications wonders *U.S. News & World Report*, April 1984

[3] Poppel, H. An Overview of Information-Age Trends and Their Impact on Telecom Managers. *Communications News*, June 1, 1985

[4] Leijnse, F. Het Nederlands hoger onderwijs in de komende tien jaar (Dutch Higher Education in the coming ten years), Een essay, *Tijdschift voor Hoger Onderwijs en Management (THEMA)* (4) 2000.

[5] William J. Baumol and William G. Bowen, *Performing Arts - The Economic Dilemma*. New York: The Twentieth Century Fund, 1966.

[6] Bruce Nussbaum. The Power Of Design. *Business Week.* May 17, 2004