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Towards Knowledge and Data Fusion Community
Knowledge Sources, Transfers and Co-Creation in Externally Funded Research and Development Consortiums

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Keywords: Adaption, Co-Creation, Continuums, Integrative Model, Knowledge Association, Knowledge Transfer, Learning by Research and Development, Partnership, Research Consortium, Resilience.

Abstract: One of the most important functions of every externally funded research consortium, e.g., FP and HORIZON, ACADEMY and TEKES, is to contribute to knowledge transfers and research and development related continuums between research programmes, higher education institutions, world of work, authorities, and actors of regional-national-union policy development and decision making. This empirical study is intended to the data and knowledge which can be transferred and co-created with participators as well as to the partnership relations of research consortium that can exploit parallel the data and knowledge sources, transfers, future continuums and high-value impacts in research-development-innovation processes. In this study, user and stakeholders needs, proactive views and operational scenarios stimulates the knowledge and data fusion user community to foster proactive involvement of stakeholders following a user-stakeholder-centric approach in the validation and utilisation of knowledge sources and transfers, addressing to: user and stakeholder needs and requirements, user experience, animated and interactive design, legacy systems connectivity, interdisciplinary and co-creativity over vary silos and mutual trust building.

1 INTRODUCTION

The important focus of higher education is on achieving a role as a co-operator and trusted partner of higher education functions, knowledge management, R&D (research and development) networks, and research consortiums and on combining useful knowledge from multiple sources and co-creating it with other participating actors for novel and beneficial competences and capabilities related to authentic R&D&I (research & development & innovation) programmes and projects, clusters, innovation systems, industry, collective research consortiums, regional-national configurations, policy development and decision making organisations and institutions.

At the center of this knowledge fusion and mobilisation is a collective way of R&D-related learning and knowledge sources and transferring. Here, the setting of this study involves R&D&I and adaptive-resilient learning integration and research consortiums as the operative environment of this study, in where the role of higher education institutions is traditionally seen as contributors of new knowledge, services models and technology. In this view, new types of action, integration, aspiration, trust, confidence and collaboration are required for the stimulation of creative and adaptive innovations in services, technology, economy and society.

In this way of "integrative learning" or "adaptive-resilient learning"; an individual learns alongside with a workplace, school and R&D community, near with a learning organization and focused learning in region-global scale. The expected advances of this integration can be associated through various formal and informal structures such as R&D networks, actors and partnerships, especially to a growing students and learners to become specialized in their areas of novel expertise where an applicable knowledge is produced and mobilised in the collective R&D related learning processes, with structures of consortiums and partnerships.

The term "integrative model" is designed here to the learner-centred and user-stakeholder-centered integration of R&D&I projects, higher education

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functions and regional-national-global development. The focus of "integrative way" is on collaborative means acting and learning in an interoperable and co-creative manner with other learners which are encouraged to develop their own ideas and train in competences to become developers and researchers at a regional-national-international level.

The "study of knowledge" is called epistemology in literature. However, no single agreed upon definition of the term "knowledge" exists; there are numerous theories to explain knowledge and its sources, paths and transfers. In this study, the rationality and motivation to the description of the realized knowledge sources, transfers, knowledge transformations and knowledge achieving approach is in usefulness of these themes and categories for the data collection, data fusion, knowledge fusion, analysis and triangulation in real R&D&I cases, research consortiums, and externally funded R&D, especially for implementation and design of thematic studies and for more resilient configuration and its integration strategy as adaptive-thematic curriculum in higher education.

2 LITERATURE

The related literature for the progress of integrative and user-stakeholder-centric data fusion community model was followed: the sense of interactions and collaborative functions of higher education institutions and regional configuration, governance policy, and strategy scenarios (Harmaakorpi, 2004); Democracy and Education (Dewey, 1916) "education is not an affair of telling and being told, but an active and constructive process"; learning to work creatively with knowledge (Bereiter, 2007); situated cognition and the culture of learning (Brown, et al., 1989); learning by expanding as an activity-theoretical approach (Engeström, 1987); the new production of knowledge (Gibbons, et al., 2008); experiential learning (Kolb, 1984): the critical theory of adult learning (Mezirow, 1981); action learning (Revans, 1982); knowledge building theory (Scardamalia and Bereiter, 2006); the school as a center of inquiry (Schaefer, 1967); metaphors of learning (Sfard, 1998); situated learning (Lave and Wenger, 2009); and interaction between learning and development (Vygotsky, 1978).

The foundation for the "knowledge economy" was introduced in the book The Effective Executive (Drucker, 1969). Drucker describes the difference between the manual worker and the knowledge worker. The manual worker, according to him, works with his hands and produces goods or services. In contrast, a "knowledge worker" works with his or her head not hands, and produces ideas, knowledge, and information. For the setting of this study, (Piore and Sabel, 1984) explains how new and flexible production technologies are transforming and transferring. References (Best, 1990) and (Porter, 1990) explain how such production networks, which are resilient and dynamic, take the form of regional or territorial production systems (Asheim, 2012; Best, 1990; Rutten and Boekema, 2012; Storper, 1997). The term "knowledge economy" and its implications for the organization of production and services are currently accepted in mainstream economic thought literature, followed (Best, 1990; Cooke and Morgan, 1998; Piore and Sabel, 1984; Porter, 1990).

As understood in the context of this study, orientation of (Schumpeter, 1939) advises five possible meanings to the term "innovation", followed: new goods; new processes; new markets; new sources of supply of new materials; and new organizational status. Article by (Tichy, 1998) maintains followed: "innovation is as organizational capability which includes: scientific; technological; socioeconomic and even cultural aspects." Reference (Geffen and Judd, 2004) advocates that, "the successes of commercialization and commercialized advantages are major determinant of innovation". Probable, the most fitting for this study is proposal by (Galanakis, 2006), which places a broader meaning to the term "innovation", such as: "the creation of new products; processes; knowledge or services by using new or existing scientific or technological knowledge, which provides a degree of novelty either to: the developer; the industrial sector; the nation or the world; or to succeed in the market place."

The foundation of higher education itself has long traditions. For example, a strong resonance of this R&D related study of knowledge transfers can be found far behind the Democracy and Education (Dewey, 1916, 33), "education is not an affair of telling and being told, but an active and constructive process." Then, Dewey continues: "Its enactment into practice requires that the school environment be equipped with agencies for doing, with tools and physical materials, to an extent rarely attained. It requires that methods of instruction and administration be modified to allow and to secure direct and continuous occupations with things. Not that the use of language as an educational resource should lessen; but that its use should be more vital and fruitful by having its normal connection with

shared activities." Reference (Revans, 1982) describes the term "action learning" which particularly obliges subjects to become aware of their own value systems, by demanding that the real problems tackled carry some risk of personal failure, so that "the subjects can truly help each other to evaluate in what they may genuinely believe" (Revans, 1982, 627).

In earlier context of this study, the action learning processes within action research frameworks were used as learning processes for development of the capabilities and professional competences of individuals, teams, overall organizations and emergent network (Lewin, 1942). In the context of this study, the term "Learning by Action Research" was understood as action learning process whereby the learner studies their own actions and experience in order to improve professional competence, capability and performance (Lewin, 1946; Mezirow, 1978; Revans, 1982). Here, learners acquire knowledge through action and practice with co-instructions, learning space, living lab, test bed, workplace, consortiums, and communities of work.

According to (Sfard, 1998, 5), the acquisition metaphor of learning is old: "Since the dawn of civilization, human learning has been conceived of as an acquisition of something." This statement addresses the act of gaining knowledge and the growth of knowledge in the process of learning, which often has been analysed in terms of concept development. Concepts are to be understood as basic units of knowledge that can be accumulated, refined and combined to form richer cognitive structures (Lewin, 1942). The learner is seen as a person who constructs meaning and knowledge. Reference (Sfard, 1998, 5) describes: "the language of knowledge acquisition and concept development makes us think about the human mind as a container to be filled with certain materials and about the learner as becoming an owner of this material." The acquisition metaphor, in terms of action, is seen as "transformation, reception, acquisition, construction, attainment, development, accumulation and grasp and the teacher should help the student to attain the appropriate goal by e.g., delivering, facilitating and conveying" (Sfard, 1998, 5). In this study, the acquisition metaphor represents a traditional view of learning in which an individual acquires abstract and generalizable knowledge by following pre-given and clear-cut rules or algorithms (Engeström, 1987; Schaefer, 1967).

The participation metaphor of learning should be viewed as a person interested in a certain kind of activity rather than in accumulating private property or possessions. Here, learning is conceived of as a process of becoming a member of a community, communicating in the language of that community, and acting according to its norms. The norms themselves are to be negotiated in the process of consolidating the community. While the learners are newcomers and reformers of practice, the teachers are preservers of the community. From the lone entrepreneur, the learners are an integral part of a group. Participation is almost synonymous with "taking part" and "being a part", and "both of these expressions signify that learning should be viewed as a process of becoming a part of a greater whole" (Sfard, 1998, 6). In the "integrative model", this perspective is involved with participation to the research consortiums, regional R&D configuration, policy development, and strategies in higher education institution (Pirinen, 2015).

Reference (Bereiter, 2007) places a knowledge-creation representation that addresses the processes of deliberate transformation of knowledge and corresponding social practices: here, the knowledge-creation metaphor of learning can be understood in way that learning is seen as analogous to "processes of inquiry, especially to innovative processes of inquiry where something new is created and the initial knowledge is either substantially enriched or significantly transformed during the process."

In this study, the knowledge creation or as its extended form knowledge co-creation approach of learning is expected to provide a way of integration of lines between problem-based, solution-based, acquisition-based, and participation-based approaches (Burr, 1995; Eraut, 1994; Gibbons, et al., 2008; Bereiter, 2007; Porter, 1990; Simon, 1996).

3 METHODOLOGY

In the operative environment of this study, the knowledge sources, knowledge transfers, triggers and enablers for co-creation were investigated in the viewpoints of research consortia, higher education institution, regional innovation system, and participated actors and students. The analysed processes in higher education were externally funded R&D projects related learning and co-creation processes, such as realization of Learning by R&D functions by solution-focused nexus. The empirical part of study was conducted on how knowledge was transferred and how co-creation exists between Learning by R&D processes and authentic cases of externally funded R&D projects

which includes strong ties to the consortium's and regional-national research agenda.

A qualitative multiple case studies were selected as the research approach. The study consists as a continuum of research interventions: the knowledge transfers in the externally funded R&D projects as single cases (n=8). The Learning by R&D processes in the higher education study units as single cases (n=18); and finally cross case conclusion of "mutual knowledge transfers" and "co-creative and continuum-focused R&D approach". This multiple case study analysis addresses the investigation of R&D-related higher education and learning realizations along with a regional-national-international research integration and included five (n=7) EU-EC funded R&D projects as cases in the domain of a higher education institution.

In this study, the multiple-case study approach was used; the method is well explained in reference sources that address "the case research strategy in studies of information systems" (Benbasat, et al., 1987); "building theories from case study research" (Eisenhardt, 1989); "case studies and theory development in the social sciences and qualitative data analysis" (Miles and Huberman, 1994); "real world research" (Robson, 2001); and "case study research design and methods" (Yin, 2009).

In this study, data on externally funded R&D were investigated and results concluded in the viewpoints of realization of R&D related activities and international-local knowledge transfers and mobilization theme. The brief description of included R&D projects as continuum of cases is described in the following Table 1. The data collection of this study was cumulative and systematically used for this qualitative analysis between January 2008 and April 2017.

Table 1: The investigated externally funded R&D projects.

R&D Project		Funding
1	RIESCA	SF-TEKES-SEC 2007-2013
2	MOBI	SF-TEKES-SEC 2007-2013
3	PERSEUS	EC-FP7-SECURITY-261748
4	AIRBEAM	EC-FP7-SECURITY-261769
5	ABC4EU	EC-FP7-SECURITY-312797
6	EU_CISE_2020	EC-FP7-SECURITY-608385
7	MARISA	EC-H2020-740698
8	#WINLandFI	SF-ACADEMY-SRC-303623

4 CONCLUSIONS

The study indicate that the characteristics and dissemination efforts by the research consortiums have a strong influence on knowledge transfer and co-creation processes and realization of R&D related learning in higher education institution, which draws collaborative links, knowledge transfers, competence improvements and shared mutual confidence and trust between participators. Strong ties within stakeholders and users, working life and higher education makes a difference to continuums and knowledge transfer functions, but for high-value impacts, working life, authorities, government relations and users participation have to be fostered and mutual confidence and trust over silos achieved in first stage in building phase of user-stakeholder community.

Study revealed that strong involvement of the larger user-stakeholder community, such as knowledge and data fusion community is needed to capture the relevant operational needs and validate the results in investigated R&D projects.

Especially, the EU funding related research consortiums relies on the large scale user-stakeholder community (national-global expertise community) that will include "end user practitioners", partners, associates, field expert, government actors, and authorities to explore and exploit the human capital in Member States and their institutions identifying operational needs, steering, scenario analysis, proactive issues, existing gaps, relevant requirements and adoptions, acceptability subjects and societal impacts that the dissemination solutions entails.

The typical design of expertise community integrates the end users' experience and design-development related R&D, trust building and co-creativity in the collective-authentic manner. The user-stakeholder community can also provide guidance to the partners and enable interactions in the consortium for the implementation of the new technologies and "legitimate peripheral participation (Lave and Wenger, 2009)" to EU research nexus and produce high-value dissemination impacts.

4.1 Knowledge Sources

The followed proposal of knowledge sources as a sample of learning within knowledge fusion expands the emergent middle range theory of knowledge sources and transfers (Pirinen, 2015) including: metaphors of learning (Sfard, 1998); knowledge building metaphor (Scardamalia and Bereiter, 2006);

learning by expanding (Engeström, 1987); situated cognition and cultural dependency (Brown, et al., 1989); and situational learning, legitimate peripheral participation (Lave and Wenger, 2009).

The study revealed that "research-learning scopes", "triggers and purposes", "research agenda", and Learning by R&D settings can address to the knowledge sources and increase knowledge transfers, such as comprised to Table 2.

Table 2: Knowledge Sources.

	Knowledge Sources (metaphors)
1	Knowledge transition and sharing: such as shared or diffused knowledge, especially in the initiation phase of research-learning activity in consortium.
2	Knowledge transformation metaphor: such as knowledge from legacy service-systems or cultures, especially in phase when the learning-scope is selected for studies.
3	Inquired knowledge: such as knowledge from domain or field; traditional metaphor of acquisition related knowledge gathering in R&D projects; exists in linear research parts of consortia knowledge processes.
4	Focused knowledge or led knowledge: such as regional R&D agenda or research consortium connected knowledge which can be adopted for radical innovations, e.g., often described in an excellence part of FP and H2020 proposal.
5	Knowledge co-creation and knowledge building: such as improving knowledge collectively upon experience, quality aspects, action data and action related competence.
6	Artifact and service related embedded-implicit knowledge: e.g., knowledge inside a service-system which can only be observed, or such as knowledge of decision trees that can be implemented artificially.
7	Knowledge by disruptive change: such as knowledge of disruptive innovations that creates a new market and related high-value network and eventually disrupts an existing market and related value network.
8	Knowledge by adaptive changes and resilience needs on-demand. Such resilience aspects as: to plan and prepare; absorb disturbance; recover from; and adapt to known or unknown threats.

4.2 Knowledge Achievements

It is noteworthy that knowledge achieving has to include a systematic and rigorous research, such as knowledge inquiries for validation of service, systems or standards. In this study, then knowledge achieving addressed to the analytic investigations and collaboration between networked research units. Then, the knowledge achievements can be described as "universal", e.g., results of case studies or design research studies in investigated R&D projects.

In investigated R&D projects, the typical outcomes of inquiry based knowledge were such as: descriptions of phenomenon or problem; specified requirements; reasoning for development; logic or models which explain phenomenon; descriptions of interest; and communal aspiration-volition. The main research questions were such as: how can "some phenomenon" be understood, modelled and realized in the operative domain.

The study revealed that achieved type of knowledge in international research setting can be further improved, modularised, transformed and utilised. The shared knowledge by research consortium can increase strengths to the related R&D projects and studies, work designs, and understanding of appropriate research gaps. The knowledge achievements were further aligned with realisations of study units, integration of word packages and facilitation of metrics in R&D projects. The main knowledge achieving elements and factors are described in Table 3.

Table 3: Knowledge Achievements.

	Knowledge Achievements (elements)
1	Led & focused knowledge sources (knowledge sources for learning scopes).
2	Research consortium related knowledge (body of knowledge).
3	Relevant requirements and needs, advices and guidance by expertise (knowledge for reasoning).
4	Knowledge for creativity and communal aspiration (knowledge for spirit and participation).
5	Knowledge of steering forums (knowledge as leadership and management driver).
6	Knowledge related to research agenda (knowledge-based steering driver).
7	Inquiries of needed new knowledge (covering of knowledge gaps).
8	Shared or diffused knowledge by value network (knowledge implications).
9	Ethical and legalisation related knowledge (knowledge for a collective policy implementation and development).
10	Analytical and science based knowledge, such as scenario analytics (rigorous).

4.3 Knowledge Transfers

It is remarkable that experiential knowledge transfers do not necessarily follow a fixed order or direction, and do not definitely complete all of the described and understood knowledge aspects in but rather knowledge transfers are in mutual interaction and all knowledge transfers include some type of learning and competence.

It can be comprised that study revealed six processes or aspects of knowledge transfers between: knowledge building (creation & co-creation); knowledge transformation (e.g. legacy alignments); knowledge achieving (e.g., inquiring, sharing and participation); and knowledge dissemination as described in Table 4.

Table 4: Knowledge Transfers.

	Knowledge Transfers (aspects | process)
1	Process from knowledge building to knowledge achieving: knowledge transfers from knowledge building (creation and co-creation) which represents as entity of thinking, ideas, aspiration and motivation to knowledge achieving which represents rigorous research and knowledge transfers which was needed for planning, designing, building, improving or testing something.
2	Process form knowledge achieving to knowledge sharing: knowledge transfers from knowledge achieving, such as research agenda or knowledge of outcomes of rigorous research to the knowledge sharing and dissemination such as proofing of relevant outcomes in terms of competence and knowledge, which were related to dissemination of services, artifacts and capabilities.
3	Process from knowledge validation to knowledge activation: knowledge transfers from knowledge validation into vary knowledge approaches; the high-value impacts of these knowledge transfers, such as new knowledge can be proved in dissemination which includes both aspects rigor and relevant.
4	Process from knowledge which is related into thinking of constructs for domain ontology development: the ontological view of the knowledge transfers takes place in the meanings of new or changed "terms" in an evolution of legacy services or artifacts, which changes the terminology and domain ontology; "new terms" are first thought, internalized, and developed inside knowledge building process.
5	Then, these "revised terms" are externalized to the collective meaning and purpose, and then expanded to the "terms" and "definitions" into more rigorous environment of research, and in the end to the "terms" which are assimilated in the context by disseminated service or artifact and finally these domain ontological knowledge achievements "terms" are transferred to the body of appropriate knowledge reserves.
6	Lastly, dissemination of terms: in the next loop, the meanings of "terms" in a new service, which were first developed by individual's mental intra-level, are then disseminated to the regional domain, and then extended to the national level, and in the end to the international level. With these ontological knowledge transfers, the meaning of a "new born term", such as "co-creation" and "resilience" what it means in this newly developed service as a view of ontology. The "new term" as "proposal of term" is extended, externalized, and synthetized from the individual understanding level to the dissemination, and in the end, to the global level and probably accepted to the global body of knowledge.

One additional finding of this study is that the value related knowledge structures would be concentrated as in manners of knowledge fusion to maximize a possible resilience for an adaptive progress and capabilities. Then as statement of study, value of new knowledge, such as intellectual knowledge, value of competitiveness related knowledge, and business related knowledge can be collocated in integrative and knowledge data fusion related models and R&D collaboration.

4.4 Knowledge Transformations

In this context, the knowledge transformations were especially enabled in the design research studies in improvements and rebuilding of legacy information systems, such as: new or revised requirements; reviewed definitions; revised or new action logic; more rigorous metric for future using; and implications for needed improvisations. In the continuum of this study, reasoning to knowledge transformation was studied and recognized by action research or case studies for design and development purposes. The description of knowledge transformations are contained to the followed Table 5.

Table 5: Knowledge Transformations.

	Knowledge Transformations (aspects)
1	Transformation of knowledge which was related to the life cycles, such as legacy systems.
2	Transformation of knowledge related to design and development path-dependency.
3	Transformation of knowledge related to system context-dependency.
4	Transformation of knowledge related to organization-institution-dependency.
5	Transformation of knowledge related to cultural-dependency.
6	Transformation of knowledge related to adaptive systems and resilience needs.

4.5 Knowledge Co-creation

Co-created knowledge or knowledge creation process, such as building of new knowledge was related to building of new artifact, service or expanded ontology in such forms as meanings of signs, symbols and constructs. The focus was on inductive approach of creation or co-creation processes, and outcomes included strong consortium-dependency, cultural-dependency, government-helix-dependency and work place dependency.

The knowledge co-creations were achieved by service design and information systems design research with multimethodological studies in R&D projects. In our co-creation settings, learning was related to processes of inquiry, especially to innovative processes of inquiry where something new was created and the initial knowledge was substantially enriched or significantly transformed during the process.

The knowledge creation or as its extended form knowledge co-creation metaphor of learning was expected to provide a way of integration of lines between problem-based, scope-based, solution-based, acquisition-based, and participation-based learning approaches.

The typical outcome of knowledge creation or co-creation approach was such as: new proposal for next externally funded project or pilot; understanding of potential solution; co-creation of new scopes; new model; description of novelty and feasibility; description of aspiration or interest; and issues to steering and shared volition. Knowledge relation to high-value impacts as dissemination effort elements in our R&D projects included such communication related understanding as described in the followed Table 6.

Table 6: Co-creation Impacts by Dissemination.

	Co-creation and Dissemination (impacts)
1	Dissemination and co-creation are functions of networked body of shared knowledge.
2	Dissemination proofs usefulness of achieved knowledge which is co-created.
3	Dissemination validates methodology for distribution of co-created artifacts and services.
4	Dissemination proofs co-created realizations.
5	Dissemination is realized by demonstrations, models and methods (samples of co-creation).
6	Dissemination meant co-validation of distribution.
7	Dissemination addressed to focused universities and schools (co-creative peripheral participation).
8	Dissemination included conferences and journal articles as deliverables to the body of knowledge.
9	Dissemination was addressed on the way to harmonization (last-mile research).
10	Dissemination was towards understanding and confirmation that how to design, build and evaluate artifacts and services.

The dissemination function includes R&D focused knowledge or thematic knowledge for future, e.g., probable new led knowledge for future continuum of studies, which can be, joined to the improvements of regional-international research agenda or future targets of research consortium and R&D projects. In addition, the dissemination and co-creative scopes were context-depended and thematic, they was achieved by studies and addressed by how and why questions and by design research interventions in R&D projects.

Then, last remark of study: an implication is that dissemination metrics should be addressed to successful realisation of artifact or service and high-value impacts in scales of direct- and indirect impacts; the R&D interventions have to include both rigor and relevant dimensions for generation of high-value impacts.

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