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Functional Frames of Learning by Research and Development

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Abstract: The research question of this multiple case study is how research and development (R&D) related functional frames can be understood and realized in learning by externally funded R&D projects. In this study, an integrative learning approach entitled learning by R&D was implemented for regional-global research collaboration in externally funded R&D projects and to improve collaborative learning and practices by R&D which can be progressed in integrative learning spaces such as shared work packages by international research consortiums. In this study, the functional frames of modern and creativity oriented higher education, R&D and regional development integration is revised and described.

Key words: case study analysis, externally funded research, functional frames, integrative learning space, knowledge transfers, learning by research and development, research consortiums

1. Introduction

This study takes a revised view to the challenges regarding to functional frames of integration of R&D, regional development and realization of study units in higher education which have changed rapidly in the years between 2003 and 2014. In this R&D related context, knowledge-based workplaces in both the economy and in society create an expanding and rapidly changing professional labor market for which higher education is expected to provide competent and capable graduates. This study includes a case study analysis of functional frames of integrated R&D and creativity oriented higher education in Finland. The focus of study is in collaborative development processes and properties of higher education functions which comprise interconnected mechanisms, events and experiences. The study was performed through the dynamics of interactions among: students and teachers; actors of research consortiums; and participators of higher education institutions, industry and government. This study describes functional frames of learning by R&D and refers to practical examples of modern higher education advances, such as: increased interaction with international research consortiums; cooperation with regional innovation system; facilitation of initiatives for knowledge-based economic development; supporting to spin-offs; dissemination of research results; and strategic alliances between the actors of the externally funded R&D and innovation systems. According this study, the revised proposal for functional frames of learning by R&D are such as: scope, context, realization, results and impacts. As remarks of study, the mechanism of international knowledge transfers between the functional frames for furthering of modern creativity oriented higher education, R&D, regional development and knowledge economy integration is undertaken.

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In this study, learning by R&D is described as an integrative way of learning in where an individual learns along with a workplace, school, and R&D community, such as a research consortium, as well as alongside a learning organization and across borders and disciplinary silos, as in a collective learning space that can be regional or individual-global oriented. The main doctrine of study is that the research dimensions include learning, and an authentic real-world research process and methodology are used for learning. Then, the objectives of learning by R&D can be associated through various formal and informal structures, such as R&D networks and actors, especially in developing students and learners to specialize in their areas of novel expertise where applicable knowledge is produced and mobilized in the collective R&D-related learning processes, which in this study are related to the externally funded R&D projects (n = 10) and research alongside of regional-national-global consortium's targets and the regional-national research agenda.

Then, the title of this study "functional frames of learning by R&D" addresses the interactive collaboration within regional-national-international innovation systems and the development of regional focused and strategic learning purposes as well as regional capabilities and R&D profiles within trust-confidence relations and with regional-national governance policy in mind. In this setting of study, learning by R&D within student-centered R&D is based on and includes R&D and research consortium collaboration, and the term "student-centered R&D" comprises a student's mind-on and hands-on activities, social interaction, creating something new in learning within R&D, and knowledge sharing and collaboration between individuals, communities of work, and global communities of R&D. The approach of this study is that learning by R&D shares a regional configuration; it employs R&D-related learning and knowledge sharing across industrial, service, and governance borders through regional-global R&D continuum integration as described in Pirinen (2008), Pirinen (2013).

This study addresses to the R&D-related learning and collaboration with higher education institutions and many other regional-national-international competence and knowledge producers, such as firms, entrepreneurs, funding organizations, and other academic institutions, focuses on the increasing importance of regional and national development and practical and scientific improvements. The significant and novel focus of higher education is on achieving a role as a cooperator and trusted partner of higher education functions, R&D 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 projects, clusters, innovation systems, industry, research consortiums, and regional and national configurations. At the center of this focus is collective and R&D-related learning. The setting of this study involves R&D and learning integration and collaboration activities with students, teachers, and regional networked R&D actors.

The term "integrative model" addresses that the three statutory tasks by the Finnish regulation(Act, 351/2003) were realized to join R&D, regional development activities, higher education functions, governance and novel R&D related pedagogy as integrated whole. Especially in this study, the term "integrative model" focuses to the student-centered integration of regional development, R&D, and higher education responsibilities. Here, the focus of an "integrative way" is on collaborative means of acting and learning in an interoperable and co-creative manner with other learners who are encouraged to develop their own ideas and train in competences to become developers and researchers at the regional-national-international level. In an integrative model, the learning transactions and increasingly R&D consortium-related knowledge transitions enable learners to contribute to their collective understanding, real targets, and regional capabilities as well as to focus on emergent innovations from their own ideas or more ready and focused lead-led innovation issues, in accordance with the themes of an international research consortium's targets and national research agenda.

The one imperative term related to the R&D based curriculum and way of learning is “thematic” which in this study is addressed to the continuum of syllabus-curriculum-regional-national-international relations, and which included collaboration, agility, mutual trust, and value in R&D collaboration. In this study, the thematic region, thematic living-labs, novel R&D activities, thematic curriculum, and thematic realizations of study units have corresponding interests in national R&D agenda and targets of international R&D consortiums. This means that learning in focused higher education is related to a body of dynamic and agile themes for thematic studies, which are important to region, consortiums, society, and innovation systems. In this way, research areas of R&D consortium’s agenda and a regional innovation system interact with the generation of new competencies, knowledge-based capabilities, regional capabilities (Harmaakorpi, 2004) and knowledge economy (Asheim, Coenen, & Moodysson, 2007) in realizations of studies in higher education.

This study is related into insights and interpretation of the term “innovation” in the context of integrative model. For this view, reference (Schumpeter, 1939) states five meanings of the term “innovation” which are: new goods; new processes; new markets; new sources of supply of new materials; or a new organizational status. In turn, reference (Tichy, 1998) relates that “innovation” is organizational capability which includes: scientific; technological; socioeconomic and even cultural aspects. Then, reference (Geffen & Judd, 2004) advocate and extend that the successes of commercialization and commercialized advantages are major determinant of innovation. However likely, most appropriate definition in this context is referenced by (Galanakis, 2006) which proposes a broader meaning for 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. Then, in this study, the term “innovation” is realized mostly in interactions of regional development as in (Galanakis, 2006) and work of research consortiums. In the integration process, the focus is on achievements for improving regional innovation capabilities, and the results of R&D transactions included student’s own or collaborative creations, such as artifacts, functionalities, work methods, designs and services. These results, in turn, often with economic supporting by regional innovation system, can later produce new regionally meaningful advantages, such as high-value impacts and more optimistically, radical innovations.

Reference (Cooke, 2004) defines a “regional innovation system” as it is consisting of integrated knowledge generation and exploitation of other regional, national, and global systems to commercialize new knowledge. This view is limited in scenes of geographical existing, as well as meaning of regional was related as nested territorially beneath. Reference (Doloreux & Parto, 2005) state that the concept of a “regional innovation system” is understood as a set for integrating public and private interests, formal institutions and organizations, as well as relationships for conducting generation and dissemination of new knowledge. Related dissertation (Teräs, 2001) focuses the sense of two kinds of knowledge transition systems, global pipelines and local buzz: This local buzz arises from the physical co-presence, facilitating the circulation of information in a local economy or community of expertise. The term “pipelines”, as also in this study, refers to channels of communication used in distant interaction, between firms and schools in network. Reference (Teräs, 2001) continued that a well-developed system of pipelines connecting the local cluster to the rest of the world is beneficial for each individual firm due to knowledge sharing relations to triple helix actors outside the cluster. In addition, it was understood in the operative environment of this study, that the more the cluster firms build up shared networks, the more new information about markets and technologies are driven into internal networks, increasing even the local buzz of the clusters itself and causalities to mutual discursions with higher education institutions (Pirinen, 2013).

In the operative environment of this study, the evolution theory of economic change, addressed on (Nelson & Winter, 1982) takes strong ties and resonance in context, it is considered here as well as in context of regional development and necessary knowledge transitions (Clark, 2007). The focus is on the path-dependent nature of competence, development and knowledge transfers. The setting of study is that the learning takes place in integrative manner in an innovation process, which is rooted in a genuine economic structure and its regional context, which includes strong elements of path dependency and thematic nature (Pirinen, 2013). In this study, the regional integration and regional development are not progressed in isolation: they rarely depend on situation, geography, historic or cultural bindings (Teräs, 2008). The operative environment of study, which is as a socially constructed system, is embedded in its historic context and involved in continuous R&D and clusters theories (Porter, 1998). Here, for purposes of this study, the assumption of path-dependent nature can be described as: "what we can do in our own way is related to where we are and then where we have been" cf. (Rickne, Laestadius, & Etzkowitz, 2012). Regarded on this study, the excepted resonance of the path-dependent approach appears in such types and forms as: body of knowledge, professional expertise, collective experience and the level of mutual trust, which can be vital to the integration of knowledge, its transforms and which all are relatively path-depended instances of regional configurations (Harmaakorpi, 2004).

The setting of this study is based on the early assumption that realization of regional development, R&D and its management is far from a linear process; instead, it is a result of a dynamic R&D process that involves interactions between several actors and things that no single actor, such as one higher education institution, can achieve or manage alone. This development includes a high level of uncertainty, unexpected events and rival implementation models, such as a "separation" model in which only dedicated units are involved in R&D and regional development in higher education institutions. Students of higher education are then at the center of the regional-global learning process, which conducts focused profiles, regional-national capabilities, and regional configuration by bridging novel knowledge and competences in a community of practice. In this study, the term "learner" refers to a student, teacher, researcher, or participant who enriches his or her own competence through collaborative R&D by sharing expertise and learning from others where R&D collaboration for learning is used, and "student" is used to indicate that a person is registered as a student in the database of the Ministry of Education and Culture. Then, as a significant key purpose of this study is to address the form of higher education that focuses on the demands of the employment market and its development, teachers and employer representatives must work together closely in an interoperative way as a collective learning community that can involve students and the implementation of study units in higher education and shared R&D, such as the activities of international research consortiums and work packages as realizations in an integrative way.

In the functional frames of this study, higher education institutions are traditionally seen as contributors of new knowledge, services, and technology. However, the future is taking place with regard to cooperation in emergent value networks, co-created innovation, the contribution of pioneering innovations, and regional development affecting social and global development. In this view, new types of learning integration, trust, confidence, and collaboration are required for the stimulation of creative innovation in services, technology, the economy, and society. In the context of this study, it was expected that research conducted by learning and usefulness of new knowledge, as different forms of R&D-related learning that are based on the demand for development of the employment market, can be used in the workplace to generate new competence and regional capability, which is the ability to do something, e.g., the regional capabilities to increase productivity and development in a region by using a research-oriented approach and support for a learner's imagination and

creativity in integrative learning transactions, especially in the sense of interactions and collaborative functions of higher education institutions and regional configuration, governance policy, and regional-national strategy scenarios (Harmaakorpi, 2004).

In the context of the study, the terms “knowledge” and “learning” refer to understanding the complexity of the operative environment to identify the influences behind various regional-global phenomena, and knowledge refers not only to the governance of contents and applications but also includes the understanding of processes and practices by which information and R&D dissemination efforts are produced. The terms “collaboration” and “shared” addresses to the realization of the authentic R&D that is implemented collectively in study units and learning in a student-centered and collective way within R&D action and regional R&D configuration settings.

In this study, the terms “integrative learning space” and, for example, “research consortium”, refer to internal, external, national, and international networks and forms of funded R&D consortia, which help participants to build their own communities of work and expertise and emergent value networks. Competent graduates of higher education would then have comprehensive expertise and capabilities in various disciplines. This implies gathering and processing information, reflecting on one’s own experiences, sharing knowledge with others, and continuously developing one’s own working methods, such as the learners’ sustainable and lifelong growth and development. These integrative learning spaces take into account the thematic targets of regional configuration, regional strategies, and the needs of workplace development.

This study furthers (Pirinen, 2013) as a post-doctoral study and investigates the interconnections of research and development (R&D) functions and frames of higher education institutions in response to the progress of information systems, security management, and service programs in perspective of higher education management effects. Then, this study addresses to the management science and innovation management as in topic of interest, such as mechanism and causalities of functional frames in integrated student-centered R&D projects in study units, which are advances by R&D collaboration and research agenda within master’s, bachelor’s, and degree education in the higher education programs of information systems and security management.

In the timeframe of this study, between 2008 and 2014, the Finnish higher education institutions and regional development integration are as well in transformation process from an advantaged regional position and national funding system into the positioning of common policies which are mostly related to the European Union, European funding systems and research programmes, such as Horizon 2020. However, in this study, the main viewpoint is that a higher education institution can have its regional related interest and complementary profiles, and own strategic focus and purpose in the global economy. In this study, it is understood that the international research collaboration can be particularly improved by shaping of higher education’s economic attraction, facilitation of R&D and international knowledge transitions. In this study, the focus and research interest were addressed to the causes and effects of functional frames of higher education and regional development integration and its investigation.

As description of path dependency of development of operative environment of this study, in Finland, the regional innovation system and regional innovation policy were mainly progressed beginning since the 1990s. The development of the regional innovation system hold strong ties to the development of the European Union, its regional and innovation policies and the reformation of the Finnish public sector. European integration and economic difficulties in the national and European economy increased the number of new possibilities for developing an innovation policy and system at the operative environment and regions.

2. Review of the Literature

The foundation of higher education and its various ways of learning has a long tradition. For example, a strong resonance for this R&D related learning theme can be found far behind the Democracy and Education (Dewey, 1916): “education is not an affair of telling and being told, but an active and constructive process.” Then, Dewey continued: “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 and information.”

Reference (Dewey, 1938) stated that teachers should participate within that learning process: the teacher’s role should not be to stand at the front of the room doling out bits of information to be absorbed by passive students. Instead, the teacher’s role should be that of a facilitator and guide. Thus, the teacher becomes a “partner in the learning process, guiding students to independently discover meaning within the subject area”, cf. (Dewey, 1897). Dewey’s definition of inquiry was as follows: “Inquiry is the controlled or directed transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole.”

Dewey explained learning from the perspective of learning by passive absorption to learning by doing; here, this “doing” is R&D-related and learning by direct contact with things as well as learning through real-life contexts and inquiry. Dewey’s classical educational theories and models had large-scale influence on later views of learning; almost none of the current learning approaches is thought to be totally new but rather seen as a continuum, e.g., learning to work creatively with knowledge (Bereiter, 2007), situated cognition and the culture of learning (Brown, Collins, & Duguid, 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 & Bereiter, 2006); the school as a center of inquiry (Schaefer, 1967), metaphors of learning (Sfard, 1998), situated learning (Lave & Wenger, 2009), and interaction between learning and development (Vygotsky, 1978).

Reference (Revans, 1982) described 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 what they may genuinely believe. In the context of this study, the action learning processes within action research frameworks (Lewin, 1946) were used as learning processes for development of the capabilities and professional competences of individuals, teams, overall organizations, and emergent networks (Lewin, 1946). Reference (Pirinen, 2009) placed the term “learning by action research”, which was understood as the action learning process (Lewin, 1942) whereby the learner studies his or her own actions and experience by reflection (Mezirow, 1981) to improve professional competence, capability, and performance. Here, learners acquire knowledge through action and practice with co-instructions, learning spaces, living labs, test beds, workplaces, and communities of work.

Reference (Sfard, 1998) used two metaphors of learning to guide the work of students, teachers, and researchers as learners: the acquisition metaphor and the participation metaphor. Here, the meaning of abstract concepts is created through the construction of appropriate metaphors. Reference (Sfard, 1998) held that

metaphors, figurative projections from the tangible or real world onto the world or universe of ideas, are the basis of understanding. Reference (Sfard, 1998) suggested that the role of the metaphor of an object in the learning and teaching processes cannot be overestimated. Reference (Sfard, 1998) stated that different metaphors may lead to different ways of thinking, and there is no clear border between metaphor and theory, here understood as middle-range theories.

Reference (Sfard, 1998) stated that the acquisition metaphor of learning is old: "Since the dawn of civilization, human learning has been conceived of as an acquisition of something" (p. 5). This statement addresses the act of gaining knowledge and the growth of knowledge in the process of learning, which often has been analyzed in terms of concept development. Concepts are understood as basic units of knowledge (Lewin, 1942) that can be accumulated, refined, and combined to form richer cognitive structures (Peirce, 1878). The learner is seen as a person who constructs meaning and knowledge. Reference (Sfard, 1998) stated that "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" (p. 5). The acquisition metaphor, in terms of R&D-related learning, 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). In this study, the acquisition metaphor represents a traditional view of learning in which an individual researcher acquires abstract and generalizable knowledge by following pre-given and clear-cut rules or algorithms and research design.

The focus of the participation metaphor is on cultural, communal, and situated aspects in learning, where activities and practices are the focus of learning (Sfard, 1998). In the context of the study, the participation metaphor emphasizes the cultural, communal, and situated aspects of learning, where activities and practices are an important part of learning. Reference (Sfard, 1998) noted, that the decision to view learning as integration with the community in action gave rise to quite a number of conceptual frameworks. In this sense, it is noteworthy that the theory of situated learning (Lave & Wenger, 2009) and the theory of situated cognition (Brown et al., 1989) have similarities with Sfard's participation metaphor: in the integrative learning space of this study, "cognition" is understood as a mental process of knowing (Bredo, 1994), including aspects such as awareness, perception, reasoning, and judgment. "Cognitive complexity" refers to the number of non-automated cognitive operations or strategies that learners must realize to achieve a specific learning goal (Lave, 1988); in turn, this "mental path dependency" is addressed in (Vygotsky, 1978).

The participation metaphor of learning should be viewed as involving a person interested in a certain kind of activity rather than in accumulating private property or possessions. Here, learning is conceived 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 negotiated in the process of consolidating the community (Vygotsky, 1978). While the learners are newcomers and reformers of practice, the teachers and R&D actors are preservers of the community. Here, participation is almost synonymous with "taking part to contribute" 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). In this study, this perspective is involved with participation in research consortiums, regional R&D configuration, policy functions, and strategies in higher education institutions.

In this study, the term "knowledge" is understood mainly in sense of "it is known that" and in sense of "the sum of what is known". Then in this study, the knowledge-creation metaphor has similarities and roots in the

creative sight of constructivism and on the critical realist and pragmatic background of inquiry and learning, which relies on interaction between individuals, communal processes, events, and mechanisms cf. (Schaefer, 1967). The described understanding of R&D-related learning is particularly based on perspectives of learning in the workplace and on the work of "the knowledge-creating company" (Nonaka & Takeuchi, 1995) and "corporate knowledge" (Tuomi, 1999). These references have focused on the creation of conceptual and cultural knowledge within processes of communities of expertise. They all agree that events, artifacts, and increasingly, service-systems are part of a community's collective knowledge, and artifacts have an effect on learning, where the focus is on building-revising knowledge. The knowledge-creation metaphor addresses a collaborative effort to enhance some subject matter, e.g., the learning scope or integrative components in learning, and it relies on an interaction between individual and communal process; it builds on a pragmatist conception of inquiry and learning conceptions, e.g., as Dewey explained.

In this study, in line with (Pirinen, 2013), the path-dependency of the knowledge and corresponding social development paths and knowledge socialization relates the knowledge-creation in R&D related learning which can be understood as meaning that learning is seen as a processes of inquiry (Dewey, 1938), especially to innovative processes of inquiry where something is created-revised and the initial path-depended knowledge is either substantially enriched or significantly transformed during the process. In this study, knowledge creation or, in its extended form, the knowledge co-creation approach (West, 2009) of learning is expected to provide a way to integrating lines between problem-based, solution-based, acquisition-based, and participation-based thinking, such as "problem-based learning" (Barrows & Tamblyn, 1980), "social constructionism" (Burr, 1995), "developing professional knowledge and competence" (Eraut, 1994), "an evolutionary approach" (Popper, 1979), and "the sciences of the artificial" (Simon, 1996).

In this study, the relatively new term "co-creativity" is used regarding collaboration, which is seen as the "secret to breakthrough creativity" (Sawyer, 2008) and leads to a group's advancements in creativity in the co-creation processes of services, artifacts, and methodology, and here, learning is placed in collaboration with innovation systems (Ståhlbröst, 2008). Reference (West, 2009) underlined that collaboration during the creative process may not be new, but the necessity of group creativity and co-creativity is: "with the information explosion and growing necessity of specialization, the development of innovations will increasingly require group interaction at some stage of the process."

For this integrative learning space, examples of the use of the research methodology continuum and the scale of the integrated research processes were described in (Pirinen, 2013). Here, for one example of realization of authentic R&D continuums in integrative model study units follow: The rigorous research was approached and integrated into the research-learning processes according to the frames of the research continuum, which included thinking and idea-building groups as a co-creation and cyclic forum (Pirinen, 2013); case study research for understanding and describing (Yin, 2009); information system design research for building, improving, and testing artifacts, services, and methodology (Hevner & Chatterjee, 2010); a last-mile research approach for general utility production that in the end addresses the value-building and economic returns on a national-global scale (Nunamaker & Briggs, 2011); and action research for the investigation of organizational and work system change and an affects caused by service or artifact implementation (Baskerville & Myers, 2004).

The expected contribution of this study consists of results as functional causalities which are concluded from analysis of interconnections and mechanisms of the knowledge transfers and examples of functional frames for activities on international R&D consortiums as well as interconnections of externally funded R&D and its effects

in support of “emerging innovations” in regional innovation system and higher education institutions.

3. Methodology

In this study, the multiple-case study approach was used. The analysis method is well known and explained in references that address the case research strategy and analysis as followed: case studies in information systems (Benbasat, Goldstein, & Mead, 1987); building theories from case study research (Eisenhardt, 1989); case studies and theory development in the social sciences (George & Bennett, 2005); qualitative data analysis (Miles & Huberman, 1994); real world research (Robson, 2002); and case study research design and methods (Yin, 2009).

In this study, the multiple case studies followed replication logic, and the selected cases as the externally funded R&D projects and related data collection serves in a manner similar to multiple experiments with similar results. Here, literal replication or contrasting results in a theoretical replication predicted explicitly at the outset of the investigation. The used form of case study analysis addressed to an understanding of a complex issue and object and it can extend experience or add strength to what is already known through previous and related research and literature. At this point, case studies emphasize a detailed contextual analysis of a limited number of events or conditions and their relationships when the relevant behavior is not manipulated and the role of the researcher is that of an objective outsider, as in Herr & Anderson (2005).

Reference (Yin, 2009) noted that the simplest multiple-case design would involve the selection of two or more cases that are believed to be literal replications, while a more complicated multiple-case design would result from more and different types of theoretical replications, such as middle-range theories (George & Bennett, 2005). In this study, the end of data collection and analysis was indicated by saturation, when no new information emerged for the research purpose (Corbin & Strauss, 2008). Then, this multiple case study analysis addresses the investigation of functional frames of R&D and its sharing along with a regional-national-international research collaboration in a domain of a higher education institution.

Reference (Gerring, 2007) states, the term “case” connotes a spatially delimited phenomenon, as a unit, observed at a single point in time or over a period of time. In this analysis, the “case” is as a functional frame of R&D. Reference (Yin, 2009) focuses, that the “case” comprises the type of phenomenon that an inference attempts to explain, here, the phenomenon is learning in higher education which is related to externally funded R&D and research by consortiums and collaborative networks. In this research setting, each individual case in each consortium may provide a single observation or multiple within case observations and evidence (Miles & Huberman, 1994). Reference (Yin, 2009) continues, that tentative definition of the “unit of analysis”, which is same as the definition of the “case”, is related to the initial question of case study research, and the unit of analysis as well as the case is relevant to the issue and main research questions itself. Here, as considering of the setting of study, the case study analysis approach appeared to be impressive for answering in our type of main research questions on “how” (and “why”) and to the research attributes by Benbasat et al. (1987).

In this research setting, case study analysis represents as initial phase of the research continuum that can be expanded in future, here, case study analysis provides an understanding of an object and can extend knowledge or add strength to what is already known through the previous continuum of research and studies (Pirinen, 2013). Then, in this view, case studies addresses to production of new knowledge for future design, functionalities, action, ontology, methods, models and theories (Pirinen, 2013). In this integrative environment, the analysis setting by (Miles & Huberman, 1994) were used similarly in the implementation of R&D related study units in the study

programs which were collectively implemented and improved by students, teachers, actors of R&D consortiums, and participators of R&D programmes and investors of external funding systems (Pirinen, 2014).

The data collection of this study was cumulative and systematically used for a qualitative analysis between January 2008and December 2014. The data were collected at Laurea University of Applied Sciences in Espoo and included five data collection themes followed: 1) data of externally funded R&D projects (n = 10) in where students, researchers and teachers were collectively participated, 2) management data files (n = 82), including strategies, drafts of visions, legislation, papers of regional focus, scoreboards, indicator, publications; 3) data on development days and reviews, n = 65 files that included measures, proposals for new measures, data displays, evaluations, reviews, learning diaries, descriptions of development targets, reports, conference and journal papers by teachers and related dissertations; 4) data from FINHEEC evaluations regarding regional development and R&D from n = 5 evaluation reports; 5) feedback data from students in n = 46 reports from the INKA system, an information system for feedback from students during different phases and areas of study; and 6) themed interviews, personal plans of master studies and conference and journal papers by students (n = 48) which focused to the analysis of integrated and student-centered R&D functions and which created educational advances such as aspiration, intention, meaningfulness, imagination, thoughts, motivation and spirit by agendas of R&D consortiums. This study takes an extended view to the functional frames of integrated and student-centered R&D projects, which were advances by R&D collaboration and agenda within master's, bachelor's and degree education in the programs of information systems (n = 530 students), security management (n = 403), and services (n = 680). Altogether there were almost 7500 students at Laurea in every year between 2010 and 2014.

The term "external validity" of this study refers to establishing the domain in which a research findings and functional frames of learning by R&D can be generalized. In this study, Laurea University of Applied Sciences in Espoo, Finland and its international R&D network as ties of research consortiums were successfully used as a research domain and as sample of higher education institution and large scale R&D integration. The overall research data collection in domain of study comprises the research data setting of investigated ten cases (n = 10) which represents as realized and externally funded R&D projects, the rationality of selection followed:

RIESCA: Rescuing of Intelligence and Electronic Security Core Applications (RIESCA) was the first of our externally funded R&D projects, running between October 2007 and March 2010. The research of RIESCA addressed a number of systems, such as transport and logistics, power and telecommunication, and hydropower and nuclear power stations, which are critical to the day-to-day functioning of any technologically advanced society such as Finland. In RIESCA, the understanding and design of the R&D consortiums as a steering driver and relationships of trust-based networked expertise were found. This project was implemented in study units in an interoperative and student-centered manner. It represents the beginning of student-centered R&D discursion in publications of the Laurea UAS (Pirinen & Rajamäki, 2010).

SATERISK: Satellite Positioning Risks (SATERISK) was initiated by two security management students at Laurea UAS. It evolved into a substantial three-year R&D project between 2008 and 2011 which was collaboratively shared with universities, an industry, and a service partner, SATERISK was funded by the Finnish Funding Agency for Technology and Innovations (TEKES). The funding of SATERISK was secured on November 14,2008 and allocated for September 1,2008 to August 31,2011. The case of SATERISK proved that, in itself, student expertise and a student-workplace relationship could be seen as a knowledge transfer bridge, a trigger, and a driver of externally funded R&D projects. Regarding this study, SATERISK has derived (FP7) spin-off, PERSEUS. Here, the focus of SATERISK is on a discovery of a path-dependency nature and a

knowledge economy in the evolution of research consortiums (Rajamäki, Pirinen, & Knuuttila, 2012).

ORE: The Open Rendering Environment case ran from June 2008 to December 2009. Rendering is the process of generating 3D images and movies on computers. The ORE project aimed to bring the Berkeley Open Infrastructure for Network Computing-based Big and Ugly Rendering Project distributed rendering service to Finland. This goal was realized by the opening of the "Render farm" service in June 2009. The Render farm service is the world's first publicly distributed rendering service advocating the use of "creative commons licenses". The ORE project also aims to help companies and universities adopt the Blender open-source 3D-modeling suite in their everyday workflow. While creating new information about social behavior and distributed computing, Laurea and the project also functioned as a pilot project for TEKES, as it studied the possibility of using a Finnish UAS as a supporting structure for bringing new technologies into the reach of small and medium-sized enterprises. ORE was the pure creation of a student, and it resulted in the establishment of a spin-off company.

CoCo: From Co-production to Co-creation (CoCo) was the most student-related research project, running between September 2010 and December 2012. Altogether, over 200 students worked together and completed the following project tasks: 120 business students were responsible for forming the project contracts at the beginning; 50 information systems students developed the Virtual Co-creation platform, and two information system interns worked as supervisors of these information systems students; 30 business students built the first draft of the analysis tool developed in the project; one business student worked as a project assistant taking care of the administration and organizing the events; and three master's degree service students service analyzed the current state of the case companies' business approach as part of their master's theses. In addition, a tool for analyzing a company's co-creation approach was developed. In this research, students were at the center of development in new roles by customers and its role change in practice. In this view, consumers and individuals take a more active role in various paths of value creation, and the focus of the value-creation processes is rapidly shifting from a supplier-company-centered view to a more customer-centered approach that aims to support customer experiences and joint value co-creation.

MOBI: The Mobile Object Bus Interaction (MOBI) ran from September 2010 to October 2013. The target of MOBI, as a Finnish national research, development, and innovation program, was to create a common information and communication technology (ICT) hardware and software infrastructure for all emergency vehicles. This infrastructure includes devices for voice and data communications, computers, screens, printers, antennas, and cabling. Additionally, interlinking with factory-equipped vehicles' ICT systems was studied. The project utilized the results of a related research project and aimed to develop product concepts that have potential in both domestic and export markets (Tikanmäki, Rajamäki, & Pirinen, 2014). The R&D scopes of MOBI have been integrated into the realization of study units since 2010. MOBI is a spin-off of RIESCA as continuum.

MACICO: Multi-Agency Cooperation In Cross-border Operations was addressed to the interactions and research and development (R&D) of security organizations and cross-border processes. The shared MACICO processes, described in this study, operates usually in dedicated networks and using of own systems and services, but which in some critical missions could directly and indirectly benefit by respective sharing of external activities, distribution of mission critical information, and sharing of information systems or information intensive infrastructure. In a short-term scenario, MACICO project was addressed to the needs for improved systems, tools and equipment for radio communication in cross-border operations and during operations which were taking place on the territory of other member states as critical over border situations. In a long-term perspective, MACICO

encompassed the interoperability issues of European countries and for formulation of transition from currently deployed legacy networks into the future broad band networks. The timeframe of MACICO was between December 2011 and December 2014.

PERSEUS: Protection of European Borders and Seas through the Intelligent Use of Surveillance (PERSEUS) is coordinated by INDRA Sistemas with n = 29 partners. The timeframe of the PERSEUS research was between January 2011 and December 2014. In this study, the selection of PERSEUS as a case represents a program and research consortium that aims at the large-scale integration, validation, and demonstration of novel systems and symbolizes European research collaboration, providing a federative frame to join research and steering in areas of significant European interest. The focus of the PERSEUS investigation is consortium functions and research on international knowledge transition and path-dependency mechanisms (Pirinen, Sivlén, & Mantere, 2014).

AIRBEAM: AIRBorne information for Emergency situation Awareness and Monitoring (March, 2011 to February, 2015) is a Seventh Framework Programme (FP7) project related to crisis management. The goal is to develop a multi-platform approach to situational awareness for crisis management, especially utilizing Unmanned Aerial Vehicles (UAVs), aerostatic platforms and satellites. In addition to EADS, the AIRBEAM Consortium includes 22 partners, including some of the largest high-tech companies in Europe. The role of Laurea is as the coordinator of Work Package 1 of AIRBEAM, which focuses on studying potential concepts of use and specifying end-user requirements. This work is in close collaboration with end-user organizations as continuum of our own budget funded MayFly pilot and studies for AIRBEAM application (January, 2009 to December 2010).

ABC4EU: Automated Border Control Gates for Europe is European Union wide R&D project and involves a Consortium of 15 partners from 8 different countries. The purpose is to make border control more flexible by enhancing the workflow and harmonizing the functionalities of automated border control gates. Project started in January 2014 and will last for 42 months. The project is led by INDRA Sistemas S.A. from Spain. During the last years, many ABC Gates have been deployed in the main European airports, most of them as pilot projects intended to test their capability to improve the border crossing processes in aspects such as speed, security, automation, and false rejection reduction. In particular, harmonization would be required in areas as e-passports management, biometrics, gate design, human interface, parallel processes, signaling and interoperability.

EU_CISE: European Union's Information Sharing Environment addresses to steps forward along the accomplishment of the European roadmap for Common Information Sharing and Distributed Systems and Services Environment. The project attains the widest possible experimental environment of innovative and collaborative services and processes between European maritime institutions and takes as reference a broad spectrum of factors in the field of European Integrated Maritime Surveillance, arising from the European legal framework, as well as from studies, pilot and related R&D projects. Timeframe of EU_CISE is between 01/06/2014 and 01/06/2017.

In this study, the research design included that the "internal validity" can be addressed to the establishment of casual relationships; the targets of the studies focused on increasing the trustworthiness and understanding that studies make sense and are credible enough for research consortiums audiences and information systems. The design of this study was based on a combination of a thorough understanding of the theoretical framework, and wide experimental knowledge, e.g., the concepts and their relationships, which were used to explain functional frames and its meaning concerning the research questions. In turn, the term "reliability" refers here to demonstrating that the operations of a study, such as the data collection procedures, can be repeated with the same results. Due to the environment and management of the research organization, the performed interventions and

spirit of action might be difficult to repeat. However, the sustain data collection of R&D projects, number of investigated cases and related themed data categories to analysis can be reflected in verification of reliability.

4. Results

The research question of this study was how research and development (R&D) related functional frames can be understood and realized in learning by externally funded R&D projects. In addressing this question, the traditional view which was reviewed by literature was included for the reflection and understanding of relations between learning and real R&D in the context of the study. The study addressed the large data collection and realizations of the security-safety related R&D projects (n = 10) and research interventions were contributed within research consortiums that were involved with R&D and interactions with study units of master's, bachelor's, and degree education in the information systems, security management, and services programs at the Laurea between 2008 and 2014. The results are first explained in this part and then functional frames and used terms are concluded to the Figure 1 in the discussion and conclusion part of this article.

Along with the investigated cases, R&D-related learning was considered in four settings: (1) traditional study unit implementation, such as training and classroom-based teaching and model-based learning; (2) learning with R&D projects carried by professional staff and realized in small-dedicated R&D units; (3) traditional casestudy-based teaching; and (4) learning by student-centered R&D with externally funded and authentic R&D projects. Laurea's main selection "(4)" of the learning approach was related to educational revolutions where authentic and collaborative ways of learning seem to develop the subjects from the early stage of the studies to competence development in the complexity of the real R&D scale. In our R&D-related learning environment, this strategic selection "learning by student-centered R&D" was expected to be as a challenging process as path of development from the classical implementation of study units to the authentic R&D-related integrative model.

In beginning, the first research findings revealed that learners can utilize better-isolated sets of information and develop R&D-related learning in which learners contribute to modern and creativity-oriented R&D and the improvement of future regional capabilities, e.g., in RIESCA, SATERISK and ORE. However, the selection of "learning by student-centered R&D" was challenging because it required not only meeting the demands of the employment sector but also training the employees and learners of the future, as well as promoting international interactions and improvements in regional development, capabilities, and R&D mobilization. Here, the strategic functional frames included such dimensions as knowledge economy, knowledge transfers and steering.

It can be stated that in operative environment of study the Gibbons mode-2 leadership mode as form of steering was implemented into the Gibbons mode-1 management institution (Gibbons et al., 2008). This implicates that besides these R&D efforts, the bottom-up and vision-relationship based management as Gibbons mode-2 was the force of a sustainable driver and also an enabler for the agile requirements in the realization processes, so that the ecosystems of different stakeholders can come up with new creative ideas, as principles understood in research of CoCo, MOBI and AIRBEAM. It is also implicated that the described knowledge transfers and achieved knowledge itself includes strong foundations of path-dependency and cultural-dependency and resonance with the knowledge economy thinking as in MACICO, PEAREUS and ABC4EU.

In the operative environment of study, the integrative process shares that knowledge and education can be preserved as a service, methodology, or product, or as educational, innovative, or intellectual assets which can be exported for a value return, e.g., in EU_CISE. Here, the incipient concept of knowledge economy includes its

support for creation and co-creation of knowledge by learners and organizational employees and its encouragement of individuals to transfer and utilize their knowledge and competencies that are in line with the goals and strategies of organizations and the regional-national R&D agenda. In this study, the term “knowledge economy” also implies the use of knowledge-intensive technologies and services, such as knowledge creation and knowledge management, to produce information-intensive economic benefits as well as new workplace creation as integrated into R&D-related themes. In macro scale, the global economy is in transition to a knowledge economy; in micro scale, higher education is transitioning to a knowledge economy of information-intensive services, products, and methodologies which are achieved in R&D regional-global collaboration.

In view of learning by R&D, a purposeful use of new information requires that it be assimilated into a sufficiently broad context, e.g., in networks and clusters, so that information is not just repeated but also understood, revised, and given value, which in the end can be understood as learning by future and direct value and impact returns. As a scenario of the main alternative view (2), if the tasks of R&D are implemented through isolated R&D units, then influences on the students and learning are challenging, cf., absorptive capabilities (Zahra & George, 2002). Here, in view (2), only small R&D units are knowledge hubs that cooperate in the field of R&D common sharing, and the core R&D processes are isolated rather than collective. Even in situations in which organizational and global-oriented learning is valued, organizations often minimize the effect of learning by establishing special and dedicated units that are isolated from core R&D processes. These dedicated units are often created to oversee organizational development, quality assurance, methodology design, risk assessment, and other valuable learning and R&D related activities. Then, these isolated departments act as reserves of competences that are rarely accessed. Since the assumption on was that, if a large number of learners at workplaces and students of higher education can be trusted to advance regional-national R&D, then more regional-global results, effects, impacts and confidence can be achieved. However, it was understood that this new knowledge economy related orientation requires increasing confidence in regional-national structures and governance policy settings.

According to the research data of this study, the R&D-related learning can provide a theoretical foundation and a set of models that can guide the integration of R&D and learning. The R&D-related learning model can extend and guide teachers’ pedagogy and pedagogical thinking in a variety of contexts that emphasize imagination-creativity relations in learning with authentic collaboration in the field of R&D. Learning by R&D can advance the integration of regional innovation systems, regional R&D institutions, and activities of R&D-oriented pedagogy in a higher education context. In perspective of implementation of study units in higher education: the contribution in R&D was in: implementation of new forms of study units; realization of models and relations of integration; and facilitation of new methods of R&D collaboration, which were created to supply for creations of emergent innovations in services, safety, technology, economy and society.

According the research data, the effective steering and knowledge transfer aspects were followed: (1) giving powers to mutual trust and motivation; (2) support to motivation, aspiration and spirit by steering frame; (3) co-creation of strategic focus and profiles of knowledge e.g., co-creative discursion with regional ties and governance; (4) strategic alignment and coordination; (5) focusing to the consortiums building and mutual interactions; (6) enablement of transformations, e.g., transformations from legacy systems, transformations from research outcomes and transformation which are related to path-dependency and cultural-dependency; (7) steering focused to creativity supporting, such aspects as: intentions, imagination, dreams, feelings, spirit, memories and thoughts by participators; (8) risk management; (9) enablement of appropriate quality system; (10) assistance of

living labs and focus groups; (11) production of evidence by monitoring and audits; (12) external funding management; (13) domain configuration; (14) dissemination management; and (15) stakeholder's management.

The founded functional frame has effects for existing enablers of qualitative or structural change in: (1) mind sets and the self of participators; (2) interactions between aspects; (3) activities; (4) knowledge structures; and (5) knowledge economy. In light of the knowledge transitions in international R&D, it would also be stated that a type of shared knowledge, action and activity changes between functional frames, which are acting as initiators and perquisites for larger R&D consortiums of interest. It is noteworthy, that functional frames can be addressed towards the repositioning of knowledge production and development of services and artifacts through the creation of study units within integration of regional development, R&D and knowledge transitions. The change in integration of study units was taking place due to: (1) cooperation in value networks; (2) co-created or emergent innovations; (3) offerings of lead innovations; and (4) especially the integration of regional development that has an impact on social and global improvements and knowledge diffusion.

In this study, the frame "scope" was expected to be useful for resiliency as for "elastic" nature and for focusing on viewpoints, learning paths, and creativity by students. The integrative learning spaces data of this study revised followed: (1) the term "scope" was useful to a satisfaction, atmosphere, mutual trust, confidence and "learning to like or dislike" in a learning space where a student takes "a scope" and makes his own personal activity, creation, improvements, and validation into the selected or shared learning target as "shared scope", e.g., as in SATERISK and ORE, which resulted from scope-based thinking; (2) a "scope" was not loaded by a teacher's knowledge in the beginning of studies, so scope-related knowledge can be composed openly by a student's viewpoints, interests, aspiration and motivation, not teacher's or problem-based viewpoints, (3) here, the term "learning scope" refers to a mental or resilient physical target or subject matter that something deals with in learning; (4) the aim of using the "elastic scopes" in the beginning of R&D related learning process as frameto support a student's imagination and creativity in learning, and the assumption was that the "elastic scope" would generate and maintain the motivation and spirit for learning, balancing the judgments and potentials of objectives, goals, and targets; e.g., the tuning of a cognitive load in a lifetime of studies would be balanced by students and teachers by "scopes"; and (5) the "scope" addresses the idea that, between two people, there is third dimension as a "scope", e.g., a model, artifact, tool, concept, or mental or social factor with which students may share, transfer and build knowledge; it communicates, activates, and motivates their personal or team learning spirit and confidence.

In this study, the revised aspects to understanding of the "our concept of scope" was that the resilient-elastic scopes can be used for interactions and dialog between participator's (1) the self, (2) schemas and (3) intuition. Here, as in psychology and cognitive science, a schema (plural schemata or schemas) was understood as an organized pattern of thought or behavior that organizes categories of information and the relationships among them. Then, the phrase "self-schema-scope" can be understood here as a mental structure of preconceived ideas, a self-steering frame representing some aspect of the world, or a system of organizing and perceiving new information. Hence, the term "schemata" influence attention and the absorption of new knowledge. The advance here is that learners are more likely to notice things that fit into their schema, while re-interpreting contradictions to the schema as exceptions or distorting them to fit, e.g., in AIRBEAM and PERSEUS. The revised implication is that the relation of "scope-schema-intuition" can advance the rapidly changing school-workplace interactions, knowledge transfers and collaborative relations in the integrative model. Then, the self-schema and intuition of learners would be aligned in line with learner's intentions, imaginings, dreams, memories, feelings, spirit and

thoughts for improving aspiration, confidence and collective motivation in learning by R&D. This can also be seen as a root to interactions, knowledge transfers, aspiration, motivation and confidence progress between workplace, higher education institution, research consortium and governance frames.

Then, with respect to the term "problem" and its usefulness, it was understood that the term "problem-based" includes much more steering by readymade and achieved knowledge, such as in the PERSEUS, AIRBEAM and ABC4EU research and results; someone knows the "problem", so the focused and led knowledge category can be used in phase of preparing studies. The implication this is that the term "scope-elastic-based" is useful for radical development and for a totally new type of solutions through students' own creations, and the terms "problem-based" and "solution-based" are useful for incremental development and "incremental invention-innovation progress".

The analysis indicates that various forms of functional frames in higher education and R&D activities can serve individuals, organizations, and entire domains. The founded aspects of functional frames includes the condition and profile that stimulate motivation and operates as sustainable innovation driver for integration of R&D and higher education functions, e.g., an effective management-leadership frame which contributes conditions for innovation drivers and stimulation of knowledge transition. As an findings of the novel scopes to the integrative processes, it can be concluded that the trigger to this R&D-related learning way would be based on (1) the creations, co-creations, and designs by students, learners and researchers; e.g., SATERISK was a student's creation; (2) the objectives of innovation and regional systems, such as lead innovations, forecast results, and novel and ready problems, such as in PERSEUS, AIRBEAM and ABC4EU; and (3) the regional R&D profiles of strategies or needed regional capabilities, e.g., in RIESCA and EU_CISE.

The theoretical contribution to the integrative model and findings of study between different frames followed: beginning from knowledge transitions from scope related cyclic frame, such as thinking, ideas and issues, to the maticcontext frame, such as R&D consortiums, regional planning groups and "co-creative designing forums"; then, from the context frame, such as R&D agenda which are supported by research consortiums, to more linear forum, such as realization of R&D and business related research; and from the realization frame to relevant results and outcomes, such as new services, artifacts as well as emergent innovations, collaborative capability, competencies, and new or improved knowledge; then, proofing events and feedback continues this iterative transition process. The outcomes of these transitions, such as new or improved artifacts or new knowledge, can be proved inside living labs in regional-national-international context; this is formed as targets in the direction of direct and indirect impacts in regional-national-global frame. Here, regardless global distribution efforts of artifacts and knowledge dissemination the path-dependency and cultural-dependency connections are increasing towards globalization (this flow is described in Figure 1 in conclusion part).

In turn, the ontological contribution to the integrative model and the knowledge transitions between frames takes place in the meanings of terms in an evolution of services or artifacts, which are first thought, internalized, and developed inside an idea or scope frame; it is then externalized to the thematic meaning and purpose, and then extended to the terms and definitions of linear R&D and consortiums language, and in the end to the terms which are assimilated in the international context of service or artifact and to the body of knowledge in an appropriate domain. Then, in the next loop, the meanings of terms in a new service, which were first developed by individual's self-mental as intra-level, are then disseminated to the regional agenda or scope in research consortium, and then extended to the national level, and in the end to the international level. As one example of the ontological transformations, the meaning of a relatively new term, such as "co-creation", what it means in this

newly developed context as a view of ontology, is extended, externalized, and synthetized from the individual schema-understanding level to the regional thematic forum, such as consortium, and in the end to the international forum and body of knowledge. So, methodology, as a way of thinking and studying, is related to phenomena which grow from the domain of practice of service or utility of artifact, and then it is also influenced and synthetized by the beliefs, attitudes, and culture of the domain. This implicates also that ontology development includes path-dependency and cultural-dependency. It is also noteworthy that the described transitions and frames do not necessarily follow a fixed order or direction, and do not definitely complete all of the frames in action, but rather the functional frames are in mutual interaction and all functional frames include elements of learning.

In this study, the next frame as a rigorous realization was approached for the sustainable development and quality. Here, the frame of the R&D and learning integration included the following continuums: (1) thinking and idea-building groups as co-creation settings (Pirinen, 2009); (2) case study research for understanding and learning (Yin, 2009); (3) information system design research for building, improving, and testing artifacts, services, methodology, inventions, and emergent inventions, e.g., design research in information systems (Hevner & Chatterjee, 2010), a design theory for systems that support emergent knowledge processes (Markus, Majchrzak, & Gasser, 2002), and systems development in information systems research (Nunamaker, Chen, & Purdin, 1991); (4) action research for the investigation of organizational and work system change with service-artifact implementation (Baskerville & Wood-Harper, 1998); and (5) a last-mile research approach for general utility production which in the end addresses the value-building, high-value real-world impacts and economic returns on a national-global scale (Nunamaker & Briggs, 2011).

The study revealed several types of advances in the R&D-related realizations: (1) increased and new forms of competences and furthered competitiveness in the regional configuration and capability setting, such as R&D capabilities, R&D skills, and R&D competences, e.g., in PERSEUS and MOBI; (2) increased trust- and confidence-related collaboration with R&D networks and innovation systems, such as a focused university strategy, a focused competence strategy, a thematic curriculum, profiled R&D scopes, a continuum of R&D themes, and research agenda-based R&D, e.g., RIESCA and PERSEUS; (3) increased cooperation in international R&D projects, e.g., PERSEUS; (4) emergent and growing collaboration between enterprises and school networks, e.g., in ORE and CoCo; (5) the integration of students' everyday activities with the development of the international interactions, e.g., conference papers, journals, special sessions and sample of evidence series; (6) a focused university strategy related to learning and new knowledge building that addressed the strategic and selected R&D themes; and (7) as a consequence, the knowledge obtained was also focused and deeper, profiled, and path-dependent; in this way, focused universities are making a difference as Clark (2008) anticipated.

In this study, a process of participating in social communities "makes resonance with" the shared cognitive processes, values, relations, trust, confidence, identity creation, and situated learning. This is noteworthy, for example, due to the long specialization of the careers and positions of networked students; they can advance the networked expertise of different requirements in the world of work and then represent the expertise organizations as an extended body of knowledge in a particular domain and research consortium. In this sense, teachers in higher education may participate and facilitate generalized advantages and discursions. Here, the study addressed the founding of the type of knowledge that is difficult to integrate with the body of knowledge at a theory-oriented university. Participation, trust, and confidence may advance work groups, communities, networks, and cultures as a unit of analysis for the investigation of learning, results and effects in the spirit of the interactions with academia, industry, service and governance.

The research findings of this study also discovered that the building of useful competence and innovation processes has become increasingly complex, multidisciplinary, trust-based, co-created, path-dependent, and globalized. Some examples include the following: (1) path-dependency in the case of SATERISK, which derived the spin-off PERSEUS and has been initialized in the case of RIESCA; (2) the trust-based networked expertise relationships and multidisciplinary approach found in RIESCA and MOBI; (3) the CoCo and ORE research projects, which focused on knowledge building in the service-artifact field by encouraging the development of competitive value co-creation service-artifact concepts and the usefulness of knowledge in a multimethodological manner; and (4) PERSEUS, ABC4EU and EU_CISE, which represents a multidisciplinary research program and a shared research consortium that targeted large-scale integration, validation, and the demonstration of novel systems and symbolizes European research collaboration, providing a common learning space to join research and steering in areas of significant European interest. In addition, the data used to investigate the ten cases connected a large variety of knowledge-competence-related paths and knowledge interconnections for innovative startups and workplaces, and there were direct implication that students and companies both were becoming global oriented.

Some of the central challenges faced by the realization of the ten R&D cases consisted of the following: (1) the establishment of a new management culture and control of the mass of projects through the R&D realizations and by higher education institutions, with trust and confidence as a key; (2) the balancing and modularizing of cognitive load and the challenges of learning in R&D realizations; (3) pedagogical development and continuous, relatively significant change in R&D that pose great challenges for teachers; (4) understanding of the meaning of student-centered R&D in communities of work and workplaces as research for work; (5) the development of incipient internationalization and individual-global interactions; (6) the measurement of the effects and development of utility, usability, and strategic measurement as an evaluation design structure in higher education; and (7) dissemination of the new R&D-related learning model in the context of higher education.

In this study, the overall properties of functional frames contribute national and regional benefits concern the creativity improvement and fields of artifacts, security and services as well as emerging innovations which were produced as cases through the dynamics of interactions and communications among higher education institution as academia, industry, and government, and on the social mechanisms, e.g., mechanism of functional frames. The latest aspects of higher education and knowledge economy in this study states, that the new undertakings and events are more service related than manufacturing based, and value co-design and co-creation would be based more on new knowledge and attractive professional growth. This relatively new perspective regarding the emerging knowledge economy refers to a focus on interactions between individuals and consumers as units of analysis in future research. In this case, not only are countries, regions, companies and universities adopting a global perspective, but also consumers, individuals and especially students in higher education.

Finally, was understood in the continuum of the ten cases that higher education institutions can increase their contribution to the innovation system; higher education institutions as a global network can keep co-creation and innovation processes alive at the regional, national, and global levels, and higher education institutions can act as incubators of entrepreneurial skills and value makers for new competences. However, the realization of these targets requires the improvement of competence and especially confidence, and this probably affects the change of action in a demanding way. It is noteworthy that regional power can be more addressed so that new and small enterprises, particularly knowledge-intensive ones, have possibility to the achievements of R&D potential and the capability to act as important actors in the innovation system. In this study, higher education institutions were understood as a “rational space” for producers of new knowledge and competences and as users of the latest

findings and bodies of knowledge in action; this gives them a role within the thematic center of the innovation system. The thematic-context nature comes from their operative action in combining knowledge from several sources, such as lead innovation systems or institutions such as strategic centers of excellence in science.

5. Discussion and Conclusion

The completed study presented here marks the beginning of unique research for collaboration and higher education functions with the R&D progress. The setting of analysis included sustainably developed quality system with the expanded data collection as body of knowledge for the continuous development of R&D activities at Laurea between 2008 and 2014. The investigation base was transparent data for progress and different measures and complementary data were comprised for analysis, including both qualitative and quantitative data. The main results of study and functional frames of learning by R&D are concluded to the Figure 1.

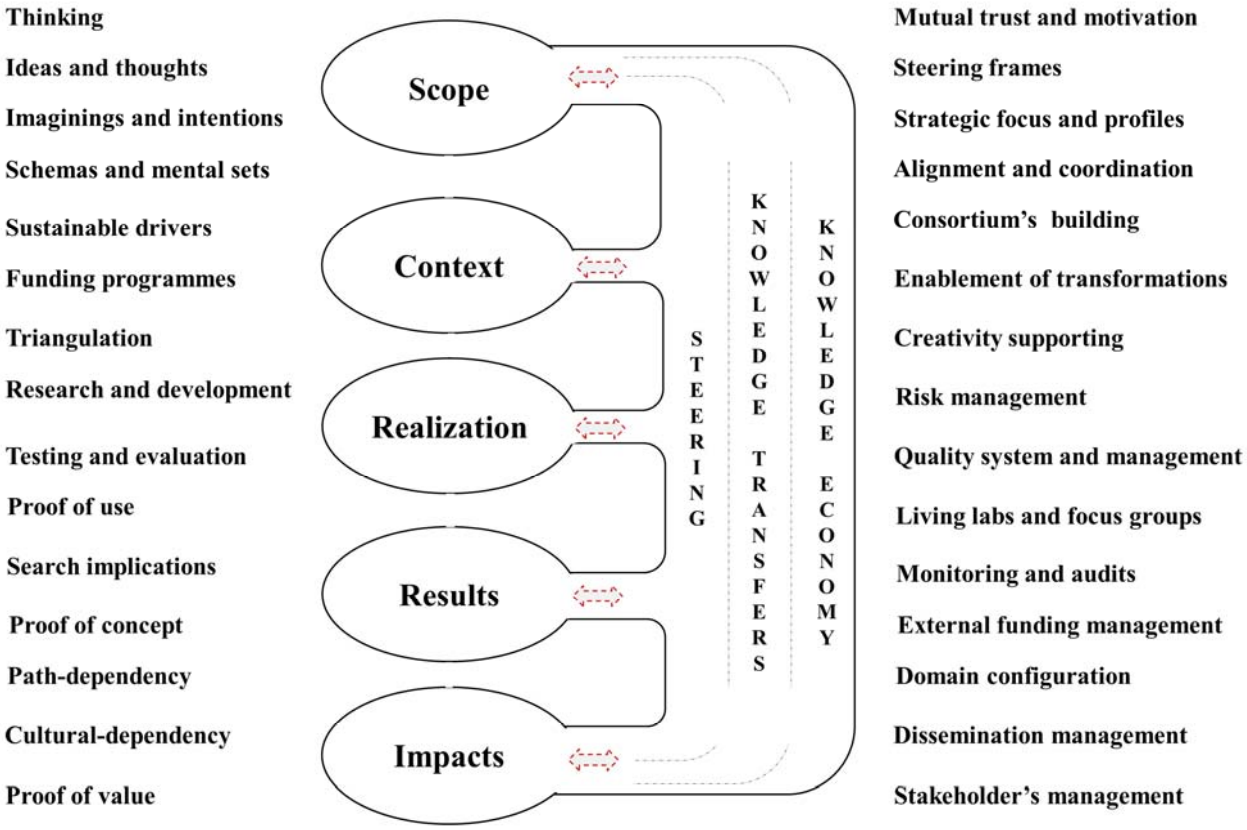

Figure 1 Functional Frames of Learning by Research and Development

This study furthered the series of studies of R&D integration in Finnish higher education institutions (Pirinen, 2013; Pirinen, 2014). Here, the progress of functional frames of learning by R&D rests to the amalgamation of R&D capabilities and regional configuration, contributing innovativeness and higher education spin-offs and initiatives for knowledge-based economic development, and strategic alliances between the actors of the regional-national-global research consortiums. The contribution of functional frames of learning by R&D is addressed towards building, improving and testing artifacts, functionalities, methodology, theories and R&D dissemination as well as towards Humboldt's integration of higher education functions and knowledge economy.

Influentially, the functional frames of learning by R&D represent an integrated learning philosophy in resonance with Humboldt's model which emphasizes collaboration with the employment sector to learn about the authentic developments and real problems encountered in the workplaces. Hence, the functional frames of learning by R&D addresses to the progress of R&D integration and knowledge transfers and the analysis, testing and developing of theories, such as path-dependency (Rickne et al., 2012) and triple helix (Etzkowitz & Leydesdorff, 1998), as well as multidisciplinary R&D methods and methodological selections for real-world and high-value impacts (Nunamaker & Briggs, 2011) in a domain of higher education institutions.

In this study, the testable theories, or testable propositions, were like theoretical hypotheses inside knowledge building and R&D integration process. The revised middle-range theory of Learning by R&D can be formed currently as an integrative way of learning; an individual learns along with a workplace, school, and R&D community, such as a research consortium, as well as with a learning organization and across borders of disciplinary and field of work silos, as a collective learning space that can be regional or individual-global oriented. Here, research includes learning, and an authentic research process and methodology are used for the settings of studies (learning) as realization frame. The objectives of learning by R&D can be associated through various formal and informal structures, such as R&D networks and actors, especially in developing students and learners to specialize in their areas of novel expertise where applicable knowledge is produced and mobilized through collective R&D related learning processes. As sample of this, the projects and realizations of this study was related to learning by externally funded R&D projects, a research consortium's targets, and the Finnish national and European Union Research agenda.

In this study, the term "integrative model", described as flow of overall in functional frames in Figure 1, was used to the student-centered integration of regional development, R&D, and higher education functions. The focus of the integrative way was on collaborative means of acting and learning in an interoperable and co-creative manner with other learners who are encouraged to develop their own ideas and motivation and train in competences to become developers and researchers at the regional-national-international level. In the integrative model, the learning transactions and increasingly R&D consortium-related knowledge transfers enable learners to contribute to a collective understanding, real targets, and regional capabilities as well as emergent innovations from student's own ideas and "lead-led innovation issues" by consortiums in accordance with the themes of an international research consortium's targets and agenda.

In realization, learning by R&D or learning within R&D addresses interactive collaboration within regional-national-international innovation systems and the development of regional-focused and strategic learning purposes as well as regional capabilities and R&D profiles within trust-confidence relations and regional-national governance policy. In this study, learning by R&D within student-centered R&D was based on and included R&D and consortium collaboration, and "student-centered R&D" referred to a student's mind-on and hands-on activities and social interaction and growing in creating something new in learning within R&D, as well as knowledge sharing and collaboration between individuals and communities of work and global communities of R&D. The approach of this study was based on the notion that learning by R&D shares a regional configuration and employs R&D-related learning and knowledge sharing across industrial, service and, governance borders through regional-global R&D continuum integration with respect to mobilization.

In Figure 1, alongside of R&D related functional frames, the five perspectives is included followed: (1) a perspective of why, which involved the reasoning of R&D through relevant scopes, focuses and profiles, the development of service-artifacts for sustainable welfare, and early middle-range theory development; (2)

viewpoints of where, which included a real context, a research consortium, an R&D agenda, the information systems domain, design and service targets, and focused objectives of the safety-security field; (3) sight of methodology as how question, which comprises in way of R&D related learning, the use of continuums of subjects, and learning by competence building for capabilities and emergent innovations, which can be realized through interactions among practice, consortium, and governance actors; and (4) viewpoints of what as results and impacts, which include results and outcomes, achieved new knowledge and business, new or improved service-artifacts and methods, new competences, functionalities and theories.

The study revealed also suggestions for further research. The furthered research setting would be that different regions in different countries may share information, international service systems, and learning spaces and flows to serve their thematic interests and targets of development within shared international research consortiums, e.g., how can Horizon 2020 be understood and realized as a continuum of functional frame to R&D focused learning spaces in the global knowledge system and at European higher education institutions (Horizon 2020 is the European Union Research and Innovation programme).

For the future remarks, the functional frames of learning by R&D can be seen as one new proficient mechanism of knowledge transfers in higher education institutions and can advance such as: (1) development of R&D capabilities; (2) joining the agenda-based R&D activities for collective education; (3) fitting together the strategies of domain, emergent R&D profiles, and education processes; (4) improvement of knowledge reserves; (5) raising the students' aspiration and participation in R&D so that they are the activating forces in the collaborative R&D; (6) teachers in continuous interaction with the environment, which allows for quick reactions to changing, agile and dynamic needs; and (7) a guide of teachers' R&D-related activities and collective thinking.

The advantages of the functional frames of learning by R&D for higher education communicate to the creativity improvement and new artifacts, services, emergent innovations, and designs that are produced through the dynamics of interactions and communications among user-consumer-centered views, academia, industry, and government. In this study, the causalities of functional frames addressed to the realization of environment with innovativeness, consisting of spin-offs and initiatives for knowledge-based economic development, and strategic alliances between the actors of regional-national R&D. The drivers of action consist of: regional innovation system; co-created strategies and emergent value networks; international pipelines; and vision-based management with co-creative discursion, transparency, conduciveness, regional R&D agenda, mutual trust, strategic selections and shared volition with stakeholders and actors.

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