Thematic Network Convergence of Knowledge for the Benefit of Society

FLACSO Mexico

Convergence of Knowledge and technologies: Approaches, dimensions and applications

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Objective of the presentation: How to understand the social process of construction of conceptual explanations in a vision of convergence, what roles the institutions and actors involved in the dissemination of the this new conceptualization play and what obstacles get in the way, which is the contribution of Social Sciences.

Questions to have in mind in the discussion:

i) What is understood on an international level as convergence; is there a global interpretation or are there differences according to country and relevant areas?

ii) Why reflect upon approaches and the concrete applications of multidisciplinary and interinstitutional collaboration on the level of sector and research groups?

iii) What perspective should be addressed in Mexico? How to design programs and funds to support research and training in opportunity sectors to deepen the approach of the convergence of knowledge. How to consolidate collaborative work between the protagonists of this paradigm, the scientific community and the productive sectors.

iv) What does the approach of the convergence in the conceptual explanation and as a guide for practical work contribute?

v) What absorption capacity of these approaches is manifest in the different areas of application? How to guide R&D collaborative work in the production process, in research and in training. What advantages can be noted y what obstacles prevent agreements and achievement of results.

vi) What instruments could be designed to systematize and measure the profundity of these collaborations? What mechanisms are convenient to evaluate these changes in research that render account of an integrating and multidisciplinary collaboration trajectory, whose quantification is not exclusively the papers individually made?

i) Delimitation of the concept

The term is new in building explanations of the scientific process. Despite an extensive bibliography from several developed countries (USA, Japan, Germany, Korea, China), in Mexico it is almost unknown, even to researchers who are working in areas of interdisciplinary convergence.
Roco’s approach et al. is structured on goals of social growth for the development of knowledge, with impact on the research in the different fields of application, in areas where convergence can develop and grow in the future. However, it is not explicit if convergence is already something that is really in progress or that in the future will allow scientific progress. In identifying the basic aspects of the convergence issue (Roco, M. C. and Bainbridge, W. S. 2001; Nordmann, A. 2004) they point out that it’s a process that extends and transforms the way different disciplines work, that traditionally functioned separately. The proliferation of connections, the impacts of globalization and the need to provide new answers to production and social demands began to create new interactions, capabilities and relational behaviors, giving way to new niches of knowledge with a collaborative character and market enhancing the emergence of new industries and clusters. This development affected services, markets, development policies, industrial structure and entrepreneurial behavior facilitating alliances and mergers. The mainstreaming of digitalization contributed to these great changes and reconstitutions that impact different industries, generating new complementarities, products and markets.

In the European Union the NBIC version was called ‘Converging technologies for the European Knowledge Society’ (CTEKS) where the areas of education, health, ICT infrastructure, environment, new sources of energy (photovoltaic, hydrogen, solar joint studies from geographers, geologists, anthropologists, smart houses). The EU’s approach (Schmidt, 2007) has a strong social and environmental component; it is not limited to the NBIC. It gives SSH an opportunity to intervene considering the contribution they provide to the understanding of the process of convergence and the

Figure 1: The approach proposed by Roco and Bainbridge in the first NBIC 2001 conference (Roco and Bainbridge, 2003; Roco and Montemagno, 2004; Bainbridge and Roco, 2006a and 2006b). The synergy combination of four large areas: Nano sciences and nanotechnologies, biotechnology and biomedicine and genetic engineering, IT including advanced computing and communications, and cognitive sciences, with implications for society, education and governance.
design of new modes of knowledge, of production, as the means to evaluate new results and processes and the dissemination of the concept in research programs.

Convergence manifests itself as an abstract concept that poses a guide for a general development of knowledge, although it is difficult to consider a determined plan in concrete applications.

NBIC’s emphasis proposes that convergence needs technological innovation to achieve human potential (Susan Jasanoff 2003, quoted by Nordmann, 2007). In contrast, the determining core of CETKS is social innovation to achieve technological potential. These approaches explain cultural differences with a universal vision. In the US and EU approaches collaboration between disciplines is decisive. The European approach introduces a more integral and interdisciplinary perspective including SSH to face social problems. While the US approach is oriented toward a new unity of science, with
reductionism towards Nano. The NBIC appears as a successor of Nano technological programs with the purpose of ensuring the continuity of funding.

The Contecs Project Converging Technologies and the impact of Social Sciences and Humanities (SSH) founded by the EU, co-ordinated by Fraunhofer ISI, Karsruhe Research Center, Business School Oxford and the École Normale Superieure, in the research conducted the role of SSH was emphasized on a wide spectrum not just on an ethical level, but as a way of contributing to the understanding and organization of the processes of knowledge and productive sectors. The CONTECS document recognizes that, in the vision of convergence, there is a gap between a very general conceptual vision and the bottom–up approach that is not yet sufficiently relieved, to explain the effects in areas of application.

The creation of an institutional structure as specific backdrops to consider SSH intervention according to CONTECS would contribute to develop a more complex vision on the development of converging technologies to strengthen innovation systems with a vision of knowledge co-evolution and cultural diversity. Cognitive Sciences (CS) though they play a prominent role in NBIC’s formulation, they haven’t played a significant role with scientists who work in nano, bio or information technologies. SSH contribution could provide new pathways to convergence to identify critical factors such as new processes of production where knowledge is inserted, evaluating dissemination in research programs, documenting different visions about convergence that arise in the collaborative process to obtain better productive, economic, and social results (improving working and training conditions) like directing funds for inter-disciplinary projects where SSH are involved.

In research conducted by CONTECS, researchers work in converging areas, they are not aware of using the concept as such. The term has been used more in the design of research policies and the creation of funds than by researchers. Convergence manifests itself on the level of doing things jointly (that is to say new structures, objects, devices) more than on a theoretical level.
Figure 3: Application in areas of CT clusters. It explains on which concrete areas the convergence approach is relevant. Convergence could imply an explanatory guideline for scientific development (top-down) or could mean something that occurs in concrete areas of application without a larger comprehensive plan (bottom-up).

Figure 4: Source CONTECS Project. Levels top-down and bottom-up, visions in the debate. The transference of methods, inputs, procedures and interdisciplinary approaches transmits new impulses in order for convergence to give way to new developments in the top-down levels. The bottom-up level is very important to investigate the nature of technological developments.
ii) What convergence means

The importance of the convergence approach gradually gains significance because of the important changes in industrial, organizational and business transformation, including costs, quality, time flexibility and reduction. An important element is the mainstreaming of information and the growing involvement of all industrial and service sectors. This digital mainstreaming introduces great changes and reconstitutions that impact different industries, generating new complementarities, products and markets.

The diversification and specialization process of knowledge, intensified with the advancement of globalization and the changes provoked by the use of science in production. The effects manifest by generating of a blurred boundary among disciplines (Hacklin, F. and Wallin, M. W. 2013; Lee, S. M., Olson. D. L., Trimi, S. 2010). In the configuration of knowledge a specialization-fragmentation-hybridization process is consolidated (Dogan, M. & Phare, R. 1990; Roco, M. C. and Bainbridge, W. S. 2001, Curran, C. S. et. at. 2010), where multidisciplinarity contributes as a relevant form in the creation of new fields of knowledge. Public policies designed in multiple industrialized countries have ensured this multidisciplinarity and collaboration to guarantee the interoperability between companies, suppliers, and reinforce connections between productive sectors and research, where the emergence of new modes of intervention and the outcome measurement reached by joint efforts are added.

The convergence of knowledge and technology is defined as the interrelation between different disciplines. It is not a fortuitous event, but the consequence of diversification and specialization, tied to the growth of economical, productive and social complexities whose demands bring about answers oriented towards the integration of different disciplines to resolve these issues (Hacklin, F. and Wallin, M. N. 2013). In the definition of the concept of convergence the interaction of multiple fields of knowledge are contemplated, which are articulated and give way to new organizational, technological, and sectorial dimensions, although they preserve a core of competences that act a technological guide (Giorgi and Luce, 2007). The notion that convergence implies a metaparadigm based on the combination of existing paradigms through new fields, constitutes a reconceptualization that transcends mature paradigms (MacGregor et al, 2013). The new paradigm based on the convergence of knowledge and technologies dilutes the boundaries between industries, contributes to the resolution of complex challenges in production and creates new niches of specialization, generating new forms of management and commercialization. This process was intensified by the progress of globalization and the changes caused by the use of science in production. Convergence implies a level of integration between different sciences that goes beyond sporadic collaborations. Therefore a building process of new tools, of generating a new language and the emergence of a new culture among researchers is manifest geared towards new common perspectives that erase the boundaries and identities between disciplines.
iii) Significant Dimensions of the convergence approach: Integration, Interdisciplinarity, and Collaboration. Institutional and cultural obstacles

The integration of knowledge in the interstices of different disciplines constitutes a critical challenge for innovation and management (Wallin, M. W. 2012) that in industrialized countries channeled into strategies of progress the sectors with high technological content to obtain competitive results on the levels of knowledge and productions.

The disciplines converge on a new hybrid field, it is not a unidirectional process, convergence implies the divergence that is started before the creation of new integrated systems and leads new competences, products and areas of application without those industries involved becoming similar. Integration goes beyond sporadic collaborations, gradually creates a language, tools, and a similar vision that strengthens a shared approach, although disciplines continue to exist, also due to bureaucratic and institutional inertia. Organizing and consolidating a real collaboration is not easy, even there aren’t many evidences of effective relayed collaboration. Institutional and cultural barriers of the country, stiffened habits of the scientific community and mechanisms of research activity control contribute.

Schummer 2004 shows that integration does not play a deciding role in publications, Beckert et al 2007 in interviews conducted with researchers proposes that the institutionalization of science is geared towards disciplines and that interdisciplinarity reproduces the existing structure. Hybrid knowledge can help the ruptures, but are not the best qualifications for the institutions and evaluating commissions of scientific production.

Germany is a country where a disciplinary vision prevails. The UK is more oriented towards problem solving with a vision of knowledge complexity. The absence of a hierarchical structure facilitates interdisciplinarity and collaboration.

Interdisciplinarity emerges as a relevant form in the search of new solutions, sustained in some industrialized countries by programs designed in public policies (industrial, of research and development, of skill training) that introduce complementarities between different industries or within subsectors of an industry (Hacklin, 2007). This movement consolidates a new way to measure results, especially in research groups. The different approaches that study the state of the art of convergence highlight the importance of this interdisciplinary dimension for knowledge, which facilitates intra and inter science collaboration.

The appropriation of this paradigm implies an organizational learning (for companies, research institutes, universities and fundamentally the academic community), an exploration of new business areas, due to the introduction of new products and services with an integrated vision. This process is not recent, although globalization, the interconnection of different areas of knowledge and industries (agriculture, manufacturing, health, services) has favored national, regional, and global expansion.

Building an integral of the converging issue is not limited to the exclusively technological field. The challenge for the Thematic Conacyt Convergence Network of knowledge for the benefit of society is to analyze the progress in different sectors (bio,
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nano, ICT and advanced manufacturing) to develop an integral perspective that considers the impact of industrial policies in the productive and organizational structure with suppliers, the effects of links achieved with the surroundings (institutional, entrepreneurial, territorial), as the importance of public-private, sectorial and intersectorial, national and state coordination, essential in the design of industrial policies and ICT.

The process of convergence implies a new dimension in collaborative and transdisciplinary work. Collaboration can link different organizations (trailblazing and supply companies, research groups and individuals) among which there can exist an interaction through platforms that shorten geographical and social distances that in the past constituted an unsalvageable difference. The systematization of new behaviors implies building new indicators to measure the process of scientific and technological convergence and its effects in the behavior of research groups and the institutions that sustain them.

The demands that the productive process present a more collaborative work that integrates multidisciplinary teams of researchers linked with the industry. Public programs geared towards R&D, such as research funds granted by organizations specialized in ICT on an international level (National Science Foundation (NSF), NASA, Marco programs, and Horizon of the EU) accompany current interest for the emergence of exchange networks whose effects reflect in the creation of new productive niches as a consequence of the density of interdisciplinary links—the changes in management and the markets that modify the form of intra and inter disciplinary work and relationships and the networking with productive sectors.

iv) Collaboration in advanced manufacturing: the aerospace sector

Collaborative engineering (Collaborative Engineering Environments CEE) is a new socio-technical engineering discipline. It facilitates the implementation of technical agreements that belong to multiple disciplines that work together to achieve a joint objective, sometimes with limited resources or opposing interests (Lu S. C-Y., Elmaraghy, W., Schuh, G., Wilhelm, R. 2007). These authors emphasize joint efforts through several cultural, geographical, and disciplinary boundaries. The approach applied by NASA to stimulate collaborative engineering is concentrated in: i) the integration of team members, ii) through software and hardware of analysis and facilities that allow the development of a specific capability of design and analysis, and iii) the ability to share data between personnel and leading Technological Centers geographically distributed through the use Virtual Private Networks (VPN). The desired goal is synchronized and asynchronous collaboration of team members distributed geographically with the integration of advanced computing, communication and technologies of analysis. Collaborative engineering substitutes other approaches previously used such as IPDT where a group of people worked together in the same place to obtain aerospace designs. The development of collaborative engineering plays an important role in the aeronautical supply chain, product data standards, SME integration in digital processes and defining functions and platform services necessary to support collaboration. The aeronautical sector contributed to define a space of reference to receive product data in the gap between companies, apart from
describing protocols of collaboration focused on exchanges between organizations and PLM concepts that support collaboration. Product Lifecycle Management (PLM) systems, applied by several aeronautical companies, imply a noninvasive system of collaboration, given that it doesn’t require changes to private systems, but allows the exchange of performance data management in collaboration of collaborative engineering. The collaboration resulted in contents of data to build the integrated design. The purpose of the project was not to redefine the whole collaboration, but to improve exchanges and communication according to the criteria that companies and people are more productive working in their own environment. The evolution of traditional engineering to collaborative engineering has been a continuous process within the history of adopting technological changes by big OEMs. The main elements that produced these transformations render an account of the technological evolution of software, the need to shorten times in order to compete in the markets and reduce costs while maintaining quality levels in production and in the track record of work groups. The complexity in the design and manufacturing of an airplane is very high, with countless components assembled within highly complex structures and manufactured, in the case of Airbus, in multiple European countries (Pardessus, T. ob. cit).

v) Obstacles for collaboration

There are no mechanisms for regulation that allow guiding a convergent vision of knowledge in fundamental R&D areas. Neither there’s an explicit support to make incursions in frontier areas.

- The lack of knowledge of researchers and the comfort that continuing to work with proven disciplinary approaches represents.

The weight of institutional barriers and the consolidation of hierarchical structures in research together with an individual cultural and evaluative vision, contribute to blocking interdisciplinary collaboration.

vi) Reflections

*Strategic decisions on an industrial and scientific policy level adopted by some industrialized countries (USA, Germany, Japan, South Korea, and Basque Country) opted for active stimulus policies for the development of channeling sectors of these paradigms make up a future competitive groundwork in the process of reindustrialization and renovation of the relationships between researches, training and productive sectors.

*Currently, improvements made in Mexico in infrastructure, technologies, behaviors and organizational flexibility respond to fragmented logics sometimes opposed that prevent achieving effective results. Frequent changes in the design of public policies and boost programs for innovation, suffer from an evaluation that recovers opportunities to continue according to the productive capabilities of the states and/or established clusters.

*The weakness in the country’s innovation system expresses a lack of information, of trustworthy relationships and knowledge exchanges (implied and coded) among
leading agents of the system of innovation (entrepreneurs, scientific community, administrators, intermediary organizations, civil society).

*Structural weaknesses in innovation reflect a lack of leadership in the capacity of the State to design actions, especially to consolidate progress already begun that stimulates selectively innovation capabilities. In Mexico there has been progress in multiple initiatives to develop receiving sectors of new technologies, the clusters created and consolidated in multiple states point to this progress, complemented by the construction of a more complex institutional structure to densify networks of collaboration and links between different productive actors, government, researchers, functionaries, business associations, and intermediary organizations. On the other hand, on the level of policies for stimulus and promotion to organized innovation through Conacyt, a series of programs and instruments were designed geared towards facilitating communication and knowledge transfer relationships between CPIs and companies that can be the seed to generate more trust in multidisciplinary results that can be achieved with actors not just from the scientific community but of a multilevel character (public-private). Among these programs, here are the ones that stand out: the organization of Thematic Networks between researchers, companies, clusters, and public and private organizations, whose action consolidates a new discussion of multidisciplinary character on the level of knowledge and relationship with the surroundings, because one goal is to gather heterogeneous agents to reflect and collaborate around an issue whose resolution implies multilevel governance. This program is joined by new initiatives also supported by Conacyt, such as the new calls about Knowledge Frontier Studies, the State Agendas of Innovation, and the creation of bilateral consortia (NSF-USA/Mexico in frontier areas) can constitute cores of discussion and joint efforts to go beyond in reflection and application of new paradigms of knowledge and make incursions in new fields where research can have an effect on a productive level and in the scientific community.

*But this support has not consolidated a vision of collaboration in research on the level of the scientific community and policy makers with the goal to enrich interdisciplinary work whose effects reach different productive sectors.