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Interdisciplinary Research-Education on Social Sciences

Knowledge Management Portal

***Abstract*—Research-education is a complex and interdisciplinary process that integrates scientific experimentation and practice into social action carried out by faculty members, whose knowledge base requires formal representation and communication processes for an interaction between the knowing subject and the knowledge object, as well as individual action schemes, in the theoretical approach of genetic epistemology. This paper describes a technological resource used to implement this process and presents its theoretical foundation (o underpinnings). This technological resource functions as an agent in the knowledge construction process and its theoretical base is grounded in a multidisciplinary perspective. It corresponds to the technological dimension of a proposal for innovating the knowledge management process and organization. This resource is based on a software engineering paradigm and conceptual perspectives rooted in technological complexity. This paper refers to some preliminary results of a utility test regarding the case of a university level academic institution that conducts not only interdisciplinary social research but also teaching activities as part of both professional training in general and the training of new researchers.**

Keywords—*component,* Technological Innovation of Process and Organization, Interdisciplinary Research-Education, Interdisciplinary Work, Knowledge Management, Complexity of Organizational Systems, Organizational Performance and Competitiveness, Higher Education.

I. Introduction

The current techno-scientific revolution has produced a hybrid between science and technology resulting from a change process in the practical structure of scientific activity [1].

This has been brought about by recent progress in Computational and Information Sciences and Telecommunications (CIST), the applications of which are expressed in the emergence and rapid evolution of Information, Computational and Communication Technology (ICCT). These changes have triggered various imbalances or "critical moments" that manifest as dysfunctional and occasionally problematic phenomena in the social system's complex functional structure. A multidisciplinary team is required to study these phenomena, and an interdisciplinary approach to explain them.

The mission of higher education institutions is to do research and assume the education of both professionals in general and new researchers in particular. These institutions are currently facing challenges caused not only by the transformation of its functional organizational structures, but also by changes in the functional cognitive disciplinary structure demanded by the complexity of current society. This has been brought about by the degree of appropriation and penetration of the ICCT.

In order to influence this transformation it is crucial and imperative to know, understand and explain technology within the social realm. As far as the scientific realm is concerned, it is currently inevitable to have knowledge, education and experience in the use, appropriation, and development of technology as well as accessibility to it.

It is evident, however, that a disciplinary perspective prevails in each of these fields. In the face of society's current complexity, we consider that this perspective is actually reductive. It excludes both the complexity of social relations and the interweaving of the elements corresponding to social realities within their own context since research is limited to a fragmented analysis of these components.

Comparatively speaking, an interdisciplinary study, the origin of which is pragmatic [2], consists of an action-oriented knowledge-generation process. Interdisciplinary studies, which are directly related to practice, aim at the use of broader perspectives for the observation and implementation of actions. The limitations of a specific discipline make it impossible to consider, understand and attend [3][4] the specificities of social phenomena, processes or situations.

In spite of the usefulness of an interdisciplinary perspective to study, understand and find solutions to social problems, and the need to influence a society's transformation, the international scientific and technological sector is still based on a functional disciplinary structure of UNESCO Catalogue of International Standard Nomenclature for Fields of Science and Technology, NI-UNESCO Version 2001 used by the Mexican National Council of Science and Technology (Consejo Nacional de Ciencia y Tecnología) to evaluate scientific and technological activity in its National Researchers' System (Sistema Nacional de Investigadores). Its use is aimed at

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meeting "the need to standardize the information generated by the National Council of Science and Technology." (See SIICYT, Sistema Integrado de Información sobre Investigación Científica y Tecnológica, CONACYT: on line).

We consider that this classification is a significant sample that reflects the functional structures in Mexico due to the Council's relevance as the supreme body ruling scientific and technological activity.

This is apparent in the different Higher Education curricula [5]. The logical inference of this approach leads us to highlight the importance of this perspective regarding the close relationship between research and education. It presents study perspectives that support the understanding, interpretation and explanation of social phenomena, as well as professional research-centered education offered in international academic spheres. Within the field of social sciences, based on specialized studies and analyses of social issues from the perspective of their own disciplinary paradigms, minimal and elective education is sporadically offered in computation, information science and communication aimed at understanding the technological factor as a promoter of current social phenomena. The opposite happens in CIST-related studies, in particular regarding ICT. ICT specializes, from a disciplinary perspective, in teaching the use, development or appropriation of technology. The study of social aspects, however, is analyzed and learned electively, if at all [6].

II. Interdisciplinary research-education [IRE]

Responding to the need to reach theoretical integration, an interdisciplinary perspective restructures disciplinary aspects [7]. This leads to the construction of new methodological procedures and the integration of terminology and concepts that result in a joint interpretation of the phenomenon which is expressed in an interdisciplinary conclusion [8]. This conclusion assumes the complexity of a demarcation of the problem; a conceptual foundation and the observation of the links between scientific research and society. All this characterizes the research team members [9].

The complexity of interdisciplinary studies brings up the need to develop new forms of cognitive functioning. For this reason academia faces the need to reformulate its conceptions and paradigms. This would reformulate the concepts, analytical dimensions and study methodologies resulting from the construction of new knowledge.

Considering that in the Mexican higher education institutions (HEI), teaching activity largely relies on faculty who also carry out research, we observe that their "influence on students depends on the concept of science that they hold, which is mostly unconscious." Thus, "the scholars' conceptions influence their research, teaching and dissemination work. Epistemological conceptions are consequently reproduced in future scientists and professionals." [10].

"From the perspective of Constructivist Epistemology, this is due to the fact that the cognisant's conceptions are expressed in his actions. The cognisant can be understood as the subject who learns, who is in ongoing interaction with reality, which he attempts to know in order to ensure ongoing adaptations, and thus balance out these exchanges." [11].

> "This is the reason why in the HEI field it becomes necessary to transmit this complex and interdisciplinary perspective among scholars dedicated to teaching activities, in order to thus influence their actions during the education of professionals and new scientists who are acquiring the capacity to explain and respond to social phenomena in a complex reality. Within this field, education for conducting complex and interdisciplinary studies favors restructuring action schemes with another panorama. It allows for the development of a global, proactive, systematized, directed and objective vision and capability which develops new skills that construct and activate new knowledge–a vision and capability referred to as Interdisciplinary Research-Education (IRE)–" [12].

III. ICCT as a means of interacting in the knowledge construction process during IRE

We consider communication as a basic and essential process for the interaction between a cognisant subject and the object of knowledge, as well as among individual action schemes that respond to the formulation described under Constructivist Epistemology. That is why we highlight and propose that ICCT-based resources have the functional capacity of an interactive agent in the knowledge construction process because they make it possible not only to instrument an interactive communication process with the transference of different knowledge representations, but also to construct virtual contexts for IRE.

IV. A process and organizational innovation proposal from a knowledge management perspective

In the face of dissonance between the need for a complex, multi- and inter-disciplinary approach and the current functional disciplinary structure prevailing in the professional curricula and syllabi in Mexican academic

institutions, the proposal is to design and innovate functional organizational structures. This design and innovation is to be based on the knowledge management approach (KM) and the development, use or appropriation of technology in all types of organizations in which multidisciplinary education and research activities are developed. This will allow the design to be applied [13][14].

In order to test the proposal's usefulness, a functional structure was designed for CEIICH's knowledge management and a telematics platform prototype was developed to operate the design. This is the interdisciplinary research-education technology platform (IRET – Tecnología de Investigación-Docencia Interdisciplinaria / TIDI in Spanish). The core theme of this paper is the theoretical foundation as well as a description of the functioning of interdisciplinary research-education technology.

The KM approach orients an organization's functioning toward the creation, evaluation and communication of information- and communication-based resources. ICCTs are essential for the application and operation of these resources. The proposal consists of creating a technological development capacity through implementing and adopting a KM method during the IRE process. This method significantly improves the production of scientific, conceptual, theoretical and methodological knowledge and supports teaching activities by reformulating the KM process that is traditionally conducted from an accounting perspective in which the type of knowledge that is constructed is referred to as Intellectual Capital. This proposal is developed within the framework of a project of UNAM's Program to Support Institutional Teaching Improvement Projects (Programa de Apoyo a Proyectos Institucionales de Mejoramiento a la Enseñanza / PAPIME) [13].

The innovation proposal addresses conceptual, methodological and instrumental dimensions. These dimensions integrate three essential elements for an organization's effectiveness, which, according to Valdés's technology management model, is its mission and functional organizational structure, as well as its technological resources and associated processes [15][16]. The proposal's instrumental dimension consists of the development of a software system with a telematic application. This system constitutes the organizational operation platform and is the interactive agent of the knowledge construction process that promotes skill transformation and creation through the multidisciplinary interaction of knowledge in the academic community (researchers, faculty, students, directors and operational personnel). The system's user graphic interphase is thus a Knowledge Management Web Portal.

In order to prove the proposal's usefulness, the PAPIME project applied it to developing CEIICH's functional KM structure design. This design considers the relationship between academic groups belonging to its internal organizational context with those groups surrounding it. During the design implementation and operation, a non-probability population sample was observed and analyzed. This sample was composed of six academic groups and a civic association, all of which were developing IRE activities: five UNAM institutional research projects; a mixed-funding CONACyT-CONAGUA project; a civil society observatory, and a SEP-CONACyT basic science research project.

The main results comprised the creation of multidisciplinary dialogue skills among social sciences and disciplines related to computational, information and communication technologies, as well as the interdisciplinary construction and reformulation of knowledge, such as basic and essential concepts. The results also included theoretical and methodological proposals that are crucial for the research problems of each of the observed projects. In addition, the capacity to identify, characterize and describe clear and well-defined technological needs was also developed in order to make this knowledge more explicit. These results led to the development of a telematics platform prototype for the operation of the functional structure set forth in the design proposed for CEIICH. This prototype corresponds to an "IRET" platform.

V. Software engineering's development phase as a complex and interdisciplinary process of interaction and interrelationship

The Iterative-Incremental model (II) is one of the Software Engineering methods undergoing continuous evolution, which places it in an avant-garde position within this disciplinary field of activity. It is one of the methods that is more widely used for software development. This model consists of four phases: the Development Cycle; Quality Evaluation and Improvement; Quality Factor Management and Association and Standards for the developed software; as well as the Optimization Phase and the measurement of the application degree [14]. This model is essential throughout all and every single one of the knowledge construction and representation phases in order to ensure the organization's effectiveness. It therefore substantially influences an organization's performance degree and quality, as well as its capacity to participate and be competitive in the social and real environment.

Particularly in the first phase, corresponding to the Development Cycle, an initial process is established consisting of a System Requirement Description. This process is not only top priority, but also essential since it articulates the multidisciplinary actions of all the groups and individuals involved in an interdependent way, both in terms of its quantity and its diversity. It thus becomes, as we have already explained, an interdisciplinary and complex action of the organizational system.

This is the reason why we consider that the main contribution of the process and organizational innovation proposal is part of this process because it substantially improves the activity and production not only of scientific, but also of organizational knowledge.

VI. Knowledge management portal

As aforementioned, the technological dimension of the innovation proposal mainly refers to the IRET system, which is proprietary software with intellectual property rights. The point of entry is the user's graphic interphase, explicitly a portal of knowledge and knowledge management that we constructed because we consider knowledge as an organizational resource to increase the value of competition [16], as well as supporting performance and development. This portal is considered part of the organizational infrastructure supporting CEIICH's evolution because "it provides the necessary functions to acquire, model, share, extract and publish scientific knowledge. Besides, it brings together all the characteristics that an organization's members need in order to access, analyze and use stored knowledge to generate new knowledge. It also contributes new experiences to the solution of common issues." All this is of course congruent with Bolisani's definition of a knowledge portal, quoted by [17].

In general terms, IRET is a module-based system in which each module corresponds to a software subsystem for each institutional research project observed during the study (see figure 1). For this reason, the knowledge management portal has microsites for each one of the IRE groups. In addition, each group's documentary information integrates into a digital library specialized by theme, and includes a closed discussion forum.

Each of these microsites is constituted by different knowledge representations. In other words, they share a common epistemological and interdisciplinary concept for each research project. This is in correspondence to the concepts, analytical dimensions and study methodologies resulting from the construction of new knowledge. For example, one of the microsites presents the research questions representing the research objective of one of the groups under observation.

It corresponds to a basic science research project currently under way which derived from the functional structure explained in the proposed organizational design. The construction of these questions resulted from the IRE interaction that one of the groups was constantly conducting, which created and reformulated the explicit knowledge representation expressed in the questions during the design of a data collection instrument. This is also another form of knowledge representation and can be observed in one of the microsites. As a result of the KM process, the same group constructed 22 main analytical criteria and 40 subsequent criteria, which in total will make it possible to analyze 62^{62} analytical correlations. Another example of the obtained results is the construction and explicit representation of analytical criteria which facilitated interdisciplinary research between political science and literature. This is within the framework of the Institutional Technological Research and Innovation project.

VII. Conclusion

I have set forth the theoretical foundation of a proposal regarding process and organizational innovation, and have mentioned some of the preliminary results obtained from the usefulness testing. The foundations highlight a perspective that is different from the "traditional and prevailing" approach referred to as Knowledge Management. This difference refers to the type of knowledge that is considered to be not only an organization's value, but also its effectiveness resource. From this traditional perspective, the notion of effective knowledge is reserved for knowledge that not only is explicit, but may also be valued in accountancy terms. This type of knowledge is called Intellectual Capital which includes patents, brands, technological innovation and computation programs, among other elements.

This notion of knowledge is the reason why in general KM is associated with organizational aspects of the private and business sector. We have nonetheless observed emerging evidence regarding how germane and useful KM theoretical and operational transference is to the sphere of non-profit organizations, particularly Academic Organizations dedicated to IRE that integrate the generation of scientific knowledge with the education of professionals and new researchers. The value of this evidence consists in demonstrating the possibility of constructing technological instruments that function as interactive agents and knowledge managers during the IRE processes because they make it possible not only to implement an interactive communication process with the transference of diverse representations of knowledge, but also to construct the necessary virtual contexts. These instruments not only lead to the production of scientific knowledge, but are also in and of themselves intellectual capital for higher education institutions.

VIII. Final consideration

Finally, and in addition to what has here been presented, I consider software development within the framework of institutional university projects both useful and pertinent, because it contributes to positioning Mexican technological development internationally. Nevertheless, the current institutional disciplinary structure creates various serious obstacles for the optimum development of the diverse phases involved in software development. Logistic hindrances add to the difficulties related to disciplinary paradigms of social science researchers prevailing in the current structure of academic organizations. Social science

researchers focus their attention on the user's graphic interphase since it is software's visible element inasmuch as it is an explicit representation of the constructed knowledge. Great enthusiasm and motivation is exhibited during the construction of this interphase, which should be noted to be arduous and requiring much time to be understood. Nevertheless, it is often forgotten that this interphase is the first element of multidisciplinary interaction that clearly defines the system's requirements. In order for software functioning to be satisfactorily completed, as a whole, other processes are required. Although the interphase facilitates the dialogue between social science researchers and the CIST, the former often neglect the important and necessary "invisible" work corresponding to the CIST researchers.

This situation hinders the execution of the evaluation, administration and optimization phases which, even at an international level, are indispensable to finishing effective software engineering with competitive quality. Occasionally, once the interphase design, as a graphic resource of the need definition process has been completed, social science researchers confuse this resource with software design and do not grant those who conduct the software engineering their due merit and authorship. Once the user's graphic interphase has been completed, it is often forgotten who provided the formally necessary resources, and who, in fact, supported the development of their capacity to understand its usefulness and technological potential for scientific research. There is confusion around the initial objective of technological development and assuming that it will be easier and that time will be saved, a decision is taken to make use of free content management software and public hosting services. This reduces the required scientific work and technological development, both at a university and national level, to the creation of a website. The use value and the positioning of foreign software in the technological sphere are thus increased. We interpret this as fostering global technological hegemony, which is in contradiction to the goal of technological democratization that often characterizes academic social science discourse.

These facts, observed during the study, demonstrate the usefulness of promoting techno-scientific work with an interdisciplinary approach. They also reveal the challenges CIST researchers face, as well as current challenges in organizational transformation within the Mexican academic organizations.

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