# Publication Networks of Engineering Academics. The Role of Graduate Students

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ABSTRACT: *The research aims to know the characteristics of the academic unit organization and its relationship with the academic outputs and the labor wellbeing.*

*The organization of the academic unit is analyzed from the proposal of Luhmann regarding autopoietic social systems, so we expect the unit to be the result of its particular form of autoreplication as a system. In addition and according with the Organizational Theory's Socio-Technical System Movement, it is expected that the academic results and the labor wellbeing are associated with the group response.*

*In order to know the academic organization and test the hypothesis, a study was made comparing historically two engineering academic units showing relevant differences of academic outputs according to the internal evaluation system of the institution of higher education (IHE) to which they belong.*

*In this report, an analysis is presented of one of the substantive academic activities: the research. The methodology used was network analysis. By the application of mathematical methods using specialized software, we obtained the representation of the publications network for each of the academic units.*

*Based upon the analysis of the publications networks of the academic units under study, we find a different response to the environment and an important difference in group response between the two units. The unit having both, a more favorable academic evaluation and group response, has a considerable number of graduate students.*

*The organization of the academic unit with more favorable results, contrary to the other one, presents a group response in a higher level, which allows them create and maintain a master and a doctorate program.*

## 1 INTRODUCTION

During the last decades, governments, all kinds of organizations and society in general, have increased in a significant way their demands on higher education institutions (HEI) and strongly questioned the quality of their services compared to their expectations.

Quality in higher education systems (HES) has been pursued mainly through government policies. The trend is also observed in the international research agenda on HES. During the last three decades it has concentrated on studies at a macro level, mainly in the relationships between the State and the HEI and in the massification of higher education, leaving an important vacuum to be filled at the micro level (Clark 1998)

Attention to the micro level of the HES is important, among other issues, because there is where academic units can be found, these considered as the cells that may contribute in a relevant way to provide a better response to the current substantive and reactive growing of higher education. Substantive growing means the development based on knowledge, whereas reactive growing refers to the expansion based on the demand of the consumers (Clark 1998).

The relevance of studying the HES at the micro level, that is the academic units, is justified by studies that have shown that the impact of government policies on the HES seems to relate to the self-managed processes of the academic units (De Vries 1998).

Due to the relationship between the academic units and its environment, inputs and outputs do not appear fundamental for the survival of the units; this may be only apparent given its complexity. Instead, we deem it appropiate to fulfill observations describing the self-referentiality of the academic units as its means of self-replication.

This paper reports, as an advance of the study of the whole organization of the academic units, an analysis of one of the substantive activities: the research. The methodology used was network analysis. By the application of mathematical methods using specialized software, we obtained the representation of the publications network of two academic units.

In the network we distinguish academics and graduate students. We are particularly interested in knowing the relationship between academics and graduate students, because they are considered part of the knowledge generating system by the academics.

This document includes four paragraphs: theoretical background and hypothesis, research methodology, results, and conclusions.

## 2 THEORETICAL BACKGROUND AND HYPOTHESIS

By academic unit is meant what Clark (1998) established as a dual cell in which an academic belongs both to a professional field, a discipline or a subject, and to an institution. Those who belong to these cells share a group of objectives and academic goals, namely research, teaching and the spreading of knowledge (PROMEP: 2002).

The academic unit is considered the basic unit of the higher education systems (Clark 1998) and the foundation stone of higher education (PROMEP: 2002)

The differentiation of the academic unit and the environment is given by the processes of generation, transmition and spreading of the knowledge pertaining to a discipline, a professional field or a subject, as well as by the self-reproduction of these same processes.

The existence of multidisciplinary academic units is acknowledged, but for the purpose of this research we will deal only with monodisciplinary units.

From the perspective of an autopoietic system (Luhmann 1984, 1995), the academic unit is observed as an operationally closed decision system, that uses its own resources (decisions) recursively to survive in a disturbing environment. This implies that the unit is the result of repetitive and rational decisions made by academics based upon their perception of the disturbances generated by their own system and environment.

The existence of this operative closing does not mean the system is independent from its environment. It means, instead, that the system is recursive, it is oriented by the same values that it himself has produced, that it has memory, that it oscillates within the scope of its own distinctions and therefore produces its own past and future (Torres-Nafarrate 2002).

The new form of relationships among systems as established by Luhmann is not in contraposition with closed and open systems, but rather the self-referential closing may produce openness (Luhmann 1984:33).

From this point of view, we may understand the differentiated answers provided by different academic units regarding the same policies of the HES and the HEI.

According to the autopoiesis model, the relationship between the HEI and the academic unit is thought as a structural link, meaning that these two systems interact without losing their identity.

The fact that both, the academic unit system and the system of the HEI, keep their identity in their interaction may be possible in loosely linked systems as established by Weick (1976) in universities. This is based upon the observation and the description by Glassman (1973 quoted in Weick:1976) who provides the image of linked events as responsive events where each keeps its own identity as well as evidence of its physical or logical separateness.

Policies in HIS act as disturbing elements of the academic unit system. The response of the academic units depends upon the perception of the disturbance by its members. Once the disturbance is perceived, the response will be created in an self-referential manner.

Based on the above, we present the following hypothesis:

a) given similar external disturbances, the organization of the system of the academic unit differentiates academic results, and

b) given similar external disturbances, the organization of the system of the academic unit differentiates labor wellbeing of academics.

The Socio-Technical Systems Movement strives for an organizational systems development including both the adequate achievement of the job and the laboral wellbeing. In this sense, it is proposed that the laboral wellbeing is contingently associated to the capacity of response of the organizations to the external demands, which can be improved more through group responses than individual responses (Eijnatten 1998).

Laboral wellbeing is defined here as laboral satisfaction, given that it is studied from the perspective of the subject of study.

Thus, we may expect that the group responses are possible contingent causes for the academic results and the labor wellbeing.

We define group response as decisions supported by the majority of the academics through the acceptance of what is proposed by the majority of the academics, and the achievement of joint actions. This definition was elaborated with contributions of the School of Behavior (Simons 1955,1978) and the Movement of Decisions and Ambiguity (March and Olsen 1989), both of which can be placed in the Theory of Organizations, and including some contributions by Luhmann (1984,1995,1997) regarding social systems and organizations.

The concept of decision is formed by two units: a) the horizon of the alternatives and its differences and b) the selected alternative (Luhmann 1997).

Standing on the publications co-authory analysis, we could infer how well the academics have been reaching agreements and realizing joint actions about investigation in each of the academic units.

## 3 RESEARCH METHODOLOGY

In order to answer the research questions and to test the hypothesis, a study was made comparing historically two units showing academic results with relevant differences according to the internal evaluation system of the IHE to which they belong.

The academic units studied were selected in such a way that they belonged to the same IHE, and even to the same department, to assure that within their environment the external disturbances would be similar.

Furthermore, to diminish the presence of confusing factors, both units were selected from the same professional field, namely engineering. It is worth mentioning that the field of knowledge of the first academic unit, chemical engineering, started its conformation as a professional field in Mexico during 1916 (Rosenblueth 1978). By contrast, the field of the second academic unit, energy engineering, is practically new at a national and internationally level, as well as the development of the associate profession (1974 up to date). The differences in the level of development of the professional fields act as a disturbing factor in our study. We try to incorporate its repercussions through a qualitative study that is currently being processed.

In this report, an analysis is presented of the results of one of the substantive academic activities: research. From the analysis, it can be inferred the grade the academics have been able to reach agreements and perform joint research.

The analysis of the research was made upon the publications of each of the groups. For chemical engineering we considered the period 1998-2002 whereas for energy engineering the period was 1997-2002.

The methodology used was network analysis, which is currently a powerful tool. Its origin may be found in the gestalt tradition with the configuration analysis of individual or group forces. It is translated to the analysis of social systems by anthropology and shows a turning point in its evolution with the development of the mathematical theory of vectors and topology, that allows the mathematical and graphical representation of the social networks (Wasserman et al. 1995)

## 4 RESULTS

By the application of mathematical methods using specialized software, we obtained the publications network for each of the academic units. Networks were built with articles published in the mentioned periods and may be found in graphs 1 and 2.

It is worth saying that in the graphs we indicate the academics of both units using a code in order to maintain as much as possible the confidentiality requested by the directors of the HEI to which these units belong.

In the development of the network we distinguish four types of actors, which are represented with different colored nodes: a) the academics of the unit being studied (red), b) the academics of the other area being studied (yellow) c) graduate students of chemical engineering (green) and d) the external researchers (blue).

The union of two actors is made through published articles in known journals, mainly international. Such articles are represented by nodes of pink color.

The number of full time professors-investigators in the energy engineering unit is 16, and in the Chemistry engineering unit is 19.

While observing graph 1 it can be noticed that the academic unit of energy engineering shows a configuration fragmented in 5 subgroups that are not related among themselves. This could mean that the research subjects are different and/or that there are no basic agreements about what research means. Both interpretations lead us to deduct that there are low levels of agreement and joint actions regarding publications and maybe in the research activities in this area. We will extend further on the issue later.

Actors in the network of the academic unit of energy engineering are: 43.1%, external researchers; 41.2%, academics of the unit being studied; 9.3%, academics of the other area being studied, and 6.4%, graduate students. It is important to point out that these percentages are related to a total of 204 co-authorships.

In graph 2, the representation of the chemical engineering network shows a configuration that links almost all the academics among each other, at least indirectly. There is only the presence of a subgroup formed by only one academic. This means that the majority of the academics of the unit is related by direct or indirect links.

Actors in the network of the academic unit of chemical engineering are: 41.5%, external researchers; 33.2%, academics of the unit being studied; 2.8%, academics of the other area being studied, and 22.5%, graduate students. These percentages are related to a total of 677 co-authorships.

However, the chemical engineering network is not intense, in the sense that all the academics are connected to each other, they do have alternate ways in which the academics may be connected.

It is worth mentioning, that the type of organizations that shows an intensive network, normally needs a big investment in internal communication time (Gil 2003), which would diminish the communication capacity of academics with other kind of actors, such as external researchers.

It is important also to note, that in chemical engineering the basic connections are established mainly by the academics of the unit, with the exception of three cases, in which the connection is given by the collaboration of a third party (AI, AA, AF).

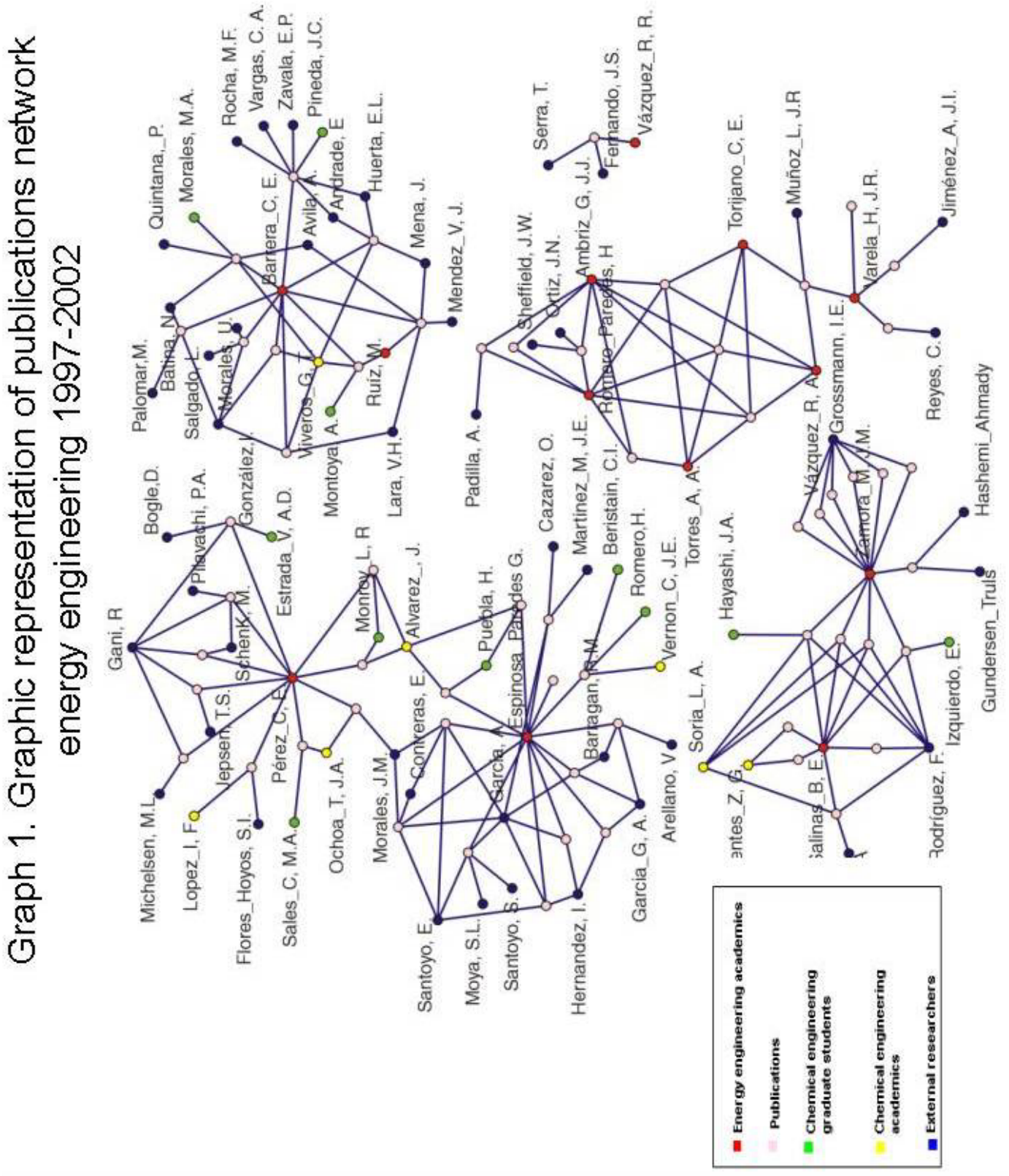
Based upon graph 2, we see that the main relationship among chemical engineering academics is not with mates of the same unit, but rather with external researchers and with graduate students. This may be expected for groups of known academics, by the prestige of keeping links with colleagues of the same research area at a national and international level. (Clark 1987, Gibbons 1994).

## 5 CONCLUSIONS

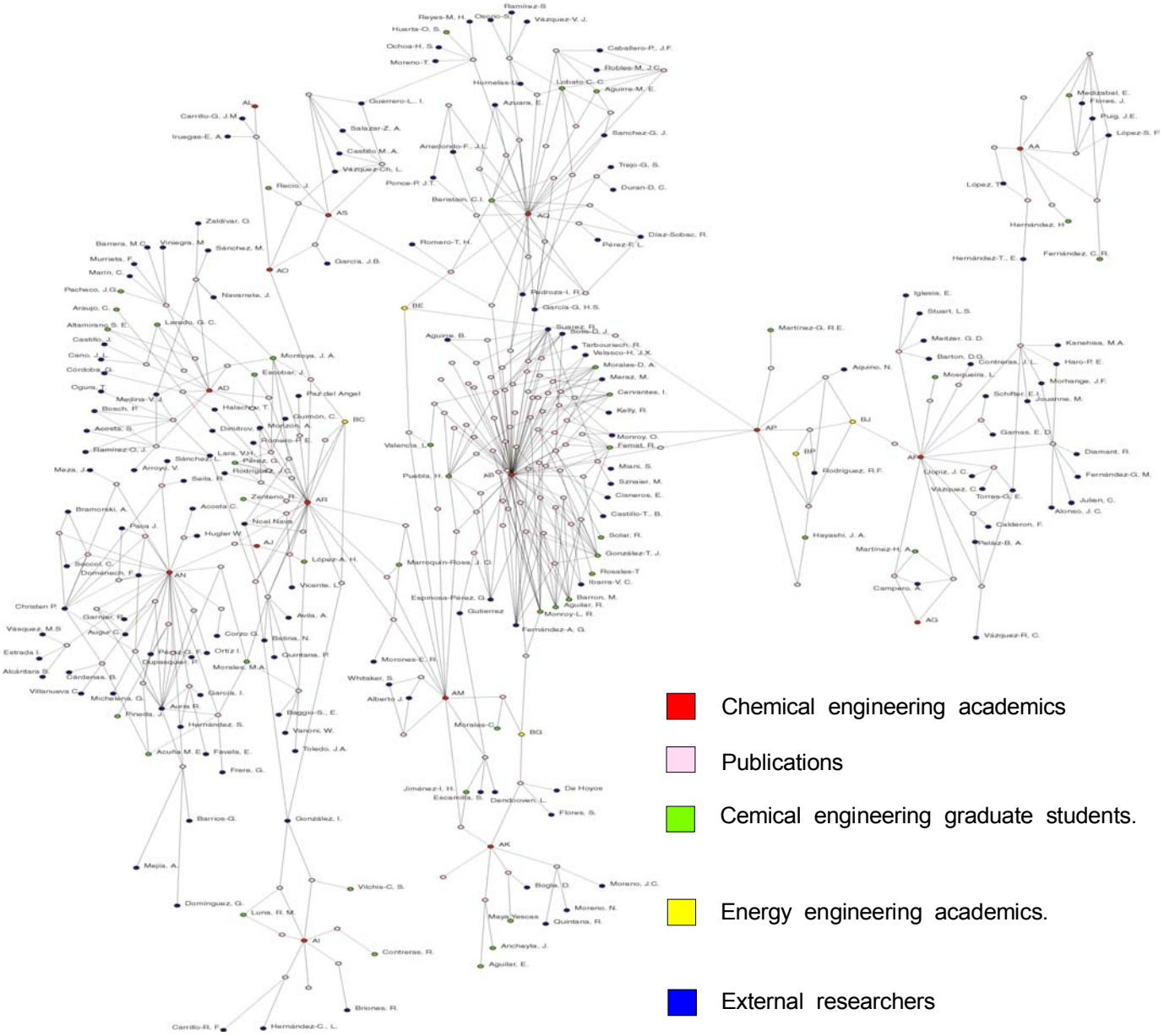
Based upon the analysis of networks of publications of the academic units under study, it can be said that we find no proof to reject the hypothesis about a different response to the similar environment and that group response is associated to the quality of the academic results. This analysis will be extended with the qualitative analysis now in process.

The configuration of the chemical engineering academic unit could be associated to a higher level of group response than the energy engineering academic unit. Although the relationships of the chemical engineering academic unit are not intensive they assure communication among almost all of the members.

Furthermore, the level of group response of the chemical engineering academic unit have allowed them create and maintain masters and doctorate studying programs. This has permitted them include students in an important way to the investigating process. As it has been showed, in the academic unit with better results the role which students have played is really important.



# Graphic . 2 representation of Chemical Engineering 1998-2002



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