

# The Inter-Unities Graduate Program in Logic and Information at Unicamp: a New Proposal

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## Abstract

This paper outlines the interdisciplinary Graduate Program in Logic and Information (Master's and Doctorate) proposed by the Centre for Logic, Epistemology and the History of Science (CLE) and the Institute of Philosophy and Human Sciences (IFCH), both units of the University of Campinas (Unicamp). The program will involve professors and researchers from diverse teaching and research faculties at Unicamp and four other public universities in the State of São Paulo, Brazil.

## 1 Introduction

The Centre for Logic, Epistemology and the History of Science (CLE) was officially established at the University of Campinas (Unicamp) in April of 1977. CLE is the first academic institution of an interdisciplinary nature in Brazil, and possibly in all of Latin America, devoted to the areas of logic, epistemology, and history of science and aiming to bring together scholars from various branches of scientific and philosophical study.

The Department of Philosophy of the Institute of Philosophy and Human Sciences (IFCH) at Unicamp was created almost simultaneously with CLE. In 1978, these two institutions implemented the first graduate program in the area of philosophy at Unicamp: the Graduate Program in Logic and Philosophy of Science. This program received the highest ratings in the institutional evaluations of the Coordinator for the Perfecting of Higher Education (CAPES, an agency of the Brazilian Ministry of Science and

Technology) and was the basis for the subsequent implantation of the Undergraduate Course in Philosophy at Unicamp.

At that time, the Department of Philosophy and CLE contained a significant group of professors and researchers of the area of logic. In addition, the Department of Mathematics of the Institute of Mathematics, Statistics and Computational Science (IMECC), now known as the Institute of Mathematics, Statistics and Scientific Computation, also had within it a significant group of logicians. In 1993, the group of logicians in Department of Mathematics transferred to the Department of Philosophy. In 1998, for institutional reasons, the Department of Philosophy created a new Graduate Program in Philosophy. Since then, logic and its diverse specialties have constituted an area of research in the Philosophy Program, and more than fifty students have received Master's and PhDs in this area.

The extensive research experience of the Group for Theoretical and Applied Logic at CLE and of the professors of logic in the Department of Philosophy at IFCH, represents thirty years of devotion to teaching and research, marked also by an emphasis on the promotion and organization of academic events, academic leadership in scientific societies, intense activity in the editing of scientific publications, and a strong international presence. All of this experience has naturally led to an interdisciplinary perspective in its widest sense, one which goes beyond the traditional limits and divisions imposed by the academic bureaucracy. This perspective incorporates a vision in which working on questions fundamental to society and global education means establishing a critical but productive dialogue among disciplines such as logic, economics, philosophy, biology, physics, computer science, and mathematics. It is an approach which naturally lends itself to the treatment of questions related to information, with its connections to logic (due to its implications for semantics and meaning), physics (energy and entropy), biology (genetic and neural information), and economics (information as capital and as commodity), as well as its epistemic aspects (due to its relation to knowledge) and its obvious philosophical implications. An interdisciplinary dialogue on these issues represents an important agglomeration of expertise with high strategic value.

For this reason, the logicians of CLE and IFCH are proposing an innovative interdisciplinary graduate program, to be named the *Inter-unities Graduate Program in Logic and Information*. This program will allow students to study for a Master's Degree in Logic and Information and a Doctorate in Logic and Information, in the following areas of concentration:

- Logical, Computational and Mathematical Aspects of Information

- Philosophical and Epistemological Aspects of Information

## 2 Objectives of the Graduate Program

The objectives of the Master's and PhD courses in logic and information will include, first of all, offering the means and instruments for specialists from different areas and disciplines to establish a dialogue based on diverse aspects of the concept of information. Second, the courses will offer students, from an interdisciplinary perspective, the theoretical and methodological foundations of the multiple dimensions of the concept of information: the definition of information and its formal problems, semantic questions of information related to the notions of meaning and truth, and social questions of information related to human behavior. Third, the course will offer an ample theoretical and methodological basis so that students will be able to do work in areas with specific problematics that touch on problems of information and communications technology.

The Master's and PhD courses of the Graduate Program in Logic and Information are *stricto sensu* graduate programs as defined within Brazilian public education, leading to the titles of Master and Doctor in Logic and Information in the areas of concentration mentioned above.

Unicamp has for many years stimulated interdisciplinary research, having achieved leadership and broad experience with regard to interdisciplinarity and its positive effect on the dialogue among the formal sciences, the natural sciences, and the human and social sciences, without leaving aside the specificity of each discipline. The innovative character of the proposed graduate program is to be found in its combining the field of logic with that of information. Logic, as is well known, is considered the “language of science”, at least within an important range of contemporary science. This is especially true in the areas of computation and information, computational linguistics, artificial intelligence, cognitive science, mathematical economics, engineering, physics, and the biology of information, in all of which it complements the traditional expressive power of the differential and integral calculus. At the same time, the interdisciplinary role of information in its multiple aspects also permeates each these areas of study.

## 3 Perspectives, Development, and Directions

The interdisciplinary doctoral course intends to attract students from different fields, chosen in virtue of their specific research projects and in ac-

cordance with the capacity of the faculty to assist them in performing their proposed research. The program has as its objective to provide the conditions for student researchers to work on the frontiers of knowledge involving diverse aspects of logic and information. It is relevant to mention here some of the characteristics of the research produced or stimulated by CLE that have influenced the intellectual project of the proposed graduate program. In particular, it is worth pointing out the international relevance of CLE, and its theoretical affinity with scholars from Unicamp, Unesp, and USP in the areas of the formal sciences (including computation and mathematics), the natural sciences (especially physics and biology), the human sciences (philosophy and the social sciences) as well as in economics and linguistics. This long and fruitful interaction, which throws into relief the interface between the formal, natural, and human sciences, is the basis for the proposed graduate program in the two specified areas of concentration, namely, Logical, Computational and Mathematical Aspects of Information, and Philosophical and Epistemological Aspects of Information. Not only the theories, methods, and perspectives of each area are relevant in this case, but the resulting interaction among scholars, which allows for innovation and for the deepening and encouraging of answers to questions related to the use, foundations, and relevance of information.

The area of logic in general, and in particular the study of specific questions related to logical systems, offers a rigorous and well established environment for the study of the flow of information. The close relationship between logic and the study of information offers a sufficiently appropriate conceptual apparatus for the control and management of the dynamics of information. On the other hand, it is clear that information only becomes privileged knowledge when combined, and in this way the investigation of logical systems and the combination of logics acquires a fundamental relevance. This line of research aims to continue the more than three decades of work by the Group for Theoretical and Applied Logic at Unicamp in paraconsistent logics, multivalent logics, diffuse logics, modal logics, logic and quantum computation, new semantic models, translations between logics, and the combination of logical systems, with priority given to the relationship with the Group's traditional European partners. It may be summarized as the investigation of robust mechanisms for the combination of non-classical logics, including the investigation of new semantic models for non-classical logics and their applications, an area of inquiry which has already shown itself to be quite relevant.

Collaboration with European and American groups is reflected in the history of publications by the Group, available for public consultation through

the Lattes Platform of the Brazilian National Council for Scientific and Technological Development (CNPq).

## 4 Program Structure

The class of disciplines offered in the proposed graduate program will cover the areas of logic and information; logic and formal ontology; logic, information, physics, and quantum computation; and philosophy of information.

Master's degree students must take a minimum of four basic required semestral courses and two electives, as well as participate in the regular Semestral Program Seminars. Courses are to be chosen in consultation with the student's advisor, and three of the six courses must be in the area of logic.

The basic required courses are:

- Introduction to Logic
- Set theory
- Computability
- Mathematical Theories of Information

Doctoral students must take a minimum of six basic required semestral courses and three electives, as well as participate in the regular Semestral Program Seminars. Aside from the four courses required of Master's degree, students studying for the Doctorate must also take:

- Non-classical logics
- Logic and Information

Among the elective classes offered, the following may be mentioned:

- Model Theory
- Probability Theory
- Metamathematics
- Non-Classical Logics (intuitionistic logic, modal logic, many-valued logics, paraconsistent logic)
- Algebra of Logic

- Philosophy of Science
- Set Theory II
- Proof Theory
- Self-Organization, Systemics, and Information
- Specialized Topics in Logic (I and II)
- Specialized Topics in Information (I and II)

With the approval of the student's advisor, the student's activities may also include classes taken at other institutions or programs. The minimum time allowed for the completion of the Master's degree is 18 months, and for the completion of the Doctorate, 30 months.

## **5 Interdisciplinarity: Network of Participating Academic Units**

To understand the conceptual framework outlined here, it is useful to distinguish the meanings of "data", "information", and "knowledge" as they are related to so-called erotetic logic (i.e. the logic of questions and answers). According to the mathematical theory of communication, information is no more than a symbol chosen from a collection of symbols, and one way in which the quantification of information is defined is given by the number of yes/no type questions necessary to determine what a certain source is communicating. A datum may be thus defined as anything that makes a difference.

As early as 1949, Shannon and Weaver, in a well - known paper, made a tripartite analysis of the notion of information in terms of: (1) mathematical questions concerning the quantification of information, as dealt with in Shannon's information theory; (2) semantic questions related to meaning and truth; and (3) questions about the impact and effectiveness of information in society and on human behavior.

Such questions raise the question of what information may be, in terms that are very close to those of other traditional philosophical questions.

Ideas about quantum physics, quantum information, and quantum computation converge, and although no quantum computer has yet been built, there are enormous latent possibilities. If instead of a computer we look for a device in which the ideas of quantum information can be explored,

then only a few quantum bits are necessary, and devices of this nature will certainly be constructed in the near future. Simple operations of two bits have been achieved in many physics experiments and work with three to ten qubits seems viable. These types of experiments can be performed in Brazilian laboratories.

Formal ontology explicitly regiments abstract conceptualization in logical models. The question then becomes, “Which logic(s) is more appropriate to formal ontology and, specifically, to the expressibility of the bases of knowledge?” Although a monist vision (usually connected to nominalist positions such as that of Quine) claims that ontologies must be committed to classical first order logic, at the present time second order logic and non-classical logics such as modal, paraconsistent, multivalent, and diffuse logics, and also the combination of logics, are being seriously taken into consideration.

In fact, if the notion of information, as mediated by methods and processes such as artificial neural networks, parallel computation, quantum computation, specialist systems, knowledge engineering, robotics, intelligent databases, cybernetics, and artificial agents, pretends to be relevant, it cannot ignore the framework of contemporary logic.

The evolution of modal, temporal, and dynamic logics, as well as of linear logic and of substructural and paraconsistent logics, has shown the high degree of advancement that can be obtained in the sciences of computation – benefits that are not only of a strictly technical nature, but also very often of major philosophical significance.

The mathematical theory of communication approaches information as a physio-mathematical phenomenon. The central question is to know if, and how much, non-interpreted data can be codified and transmitted efficiently by means of a determined alphabet and through a determined channel. The mathematical theory of communication is not interested in the meaning, content, relevance, usefulness, or interpretation of information, but only in the level of detail and frequency of the non-interpreted data, these being symbols, signals, or messages.

On the other hand, philosophical approaches seek to account for information as semantic content, investigating such questions as “How can something count as information, and why?”, “How can something contain information about something else?”, “How can information relate to truth, error, and knowledge?”, and “How much information is useful?”

The philosophy of information constitutes a new area of investigation, whose role is not only the analysis and interpretation of the conceptual questions and problems emerging in the information society, but also of

the concept of information itself in its relationship to the philosophy of mathematics and the philosophy of logic, as well as to recent theory of self-organization.

In this sense, the *Inter-unities Graduate Program in Logic and Information* intends to seriously investigate the complexity of scientific and conceptual dynamics through a dialogue between the formal sciences (including logic and computation) and the natural sciences, philosophy, and the economic sciences.

It is from this perspective that the present proposal has the objective of implementing at Unicamp a Master's and Doctoral program in logic and information, with the institutional involvement of the Centre for Logic, Epistemology and the History of Science (CLE) and the Institute of Philosophy and Human Sciences (IFCH). The program will also count on the participation of teachers and researchers from other units of Unicamp concerned with the broad thematic area that the program proposes to investigate, such as the Institute of Mathematics and Scientific Computation (IMECC), the Institute of Physics (IFGW), the Institute of Language Studies (IEL), the Faculty of Electrical Engineering and Computation (FEEC), the Institute of Economics (IE), the Faculty of Applied Sciences (FCA), and the Faculty of Technology (FT).

In addition, among its faculty the program will include teachers and researchers from four other public universities in the State of São Paulo: the Department of Philosophy of the State University of São Paulo (UNESP, Marília Campus), the Department of Computation of the University of São Paulo (USP), the Department of Philosophy of the Federal University of ABC (UFABC, São Paulo), and the Department of Mathematics of the Federal University of São Paulo (Unifesp, São Paulo).