A PROPOSAL FOR AN UNDERGRADUATE DEGREE IN THE USES OF LOGIC

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This proposal is an attempt to reconsider from first principles the purpose of higher education for the development of general problem-solving abilities rather than for specific vocational skills. As such it is only a discussion document and not a concrete proposal for adoption by the Department of Computing at Imperial College.

Objectives. The goal is to train students in the general skills of logical reasoning, problem-solving and effective communication, which can be applied in any discipline, but especially in business and administration. It would be more practical than a conventional course in pure mathematics, philosophy or formal logic, and more rigorous than a course in business studies, languages or social studies.

The problem. The majority of graduates never undertake employment in their field of study. Many others change their field of work sometime after completing their studies. The benefits of higher education for most graduates, therefore, consist largely of improved general powers of reasoning, problem-solving and communication learned implicitly in the context of a discipline which is rarely exercised after graduation.

We have a related problem in my own discipline of computing. The subject is sufficiently mature that professionals now require specific knowledge, which is best gained from academic studies, not so much to learn individual programming languages as to develop general techniques and methodologies.

But not all computer scientists are convinced that the best training for their field is a degree in computing. Many of us would prefer students to complete an undergraduate degree in mathematics, followed by a conversion course in computing. Such training in mathematics provides a better foundation for rigorous problem-solving, at the expense, however, of a largely irrelevant subject matter.

The solution. The obvious solution, to teach logic as a discipline in its own right, doesn't seem to work. Traditional academic logic is too abstract, too mathematical and too remote from every day life.

The answer is to develop a more practical course in the uses of logic, based upon recent advances in artificial intelligence, computing and linguistics. These new developments reinforce allied applications of logic in more traditional disciplines such as mathematics, philosophy, human communications and law. At a first approximation the proposed course would combine these seven areas with formal logic and the use of logic as a computer language.

Artificial intelligence. Until recently there have been two main kinds of research activity in artificial intelligence: one oriented towards engineering, concerned with constructing computer systems of greater functionality; the other, oriented towards cognitive science, concerned with building computational models of human intelligence. These two kinds of studies are beginning increasingly to interact through the identification of systematic problem-solving techniques which can also be used to improve human problem-solving behaviour. Most of these techniques are based upon practical applications of computational logic and have begun to result in the development of expert systems and of computer programs which process natural languages such as English.

Computing. In the same way that the use of low-level machine languages gave way to high-level programming languages, programming languages in turn are giving way to specification languages and database query languages. This represents a shift from the programmer explaining **how** a problem should be solved to the user specifying **what** the problem is. The mechanization of formal logic plays the central role both in representing knowledge and in determining how the problem should be solved. This development is similar to related developments in artificial intelligence, with logic programming serving as a link between these two areas.

Linguistics. Paralleling the development of natural language understanding systems in artificial intelligence, emphasis in linguistics has been shifting from syntax to semantics and pragmatics and from analysis of individual sentences to analysis of text and discourse. Logic and deduction play an increasingly important role in theories of how new information is understood in context. Perhaps the most important of these, relevance theory, bears a striking resemblance to logic-basic theories of truth maintenance and knowledge assimilation in artificial intelligence.

Human Communication. Whereas linguistics aims to describe the human use of language, effective human communication requires normative theories of how humans can express themselves more effectively. It can be argued that descriptive theories based on the deductive model of language comprehension can also serve as normative theories explaining and improving the principles of good writing style presented in such classics as Strunk and White's "The elements of style" and Sir Ernest Gower's "The complete plain words". In relevance theory terms, effective communication is achieved by conveying maximum information with least deductive processing in the context of a hearer's or reader's knowledge and beliefs. This implies, for example, such principles of communication as avoiding ambiguity, preferring the concrete to the abstract, eliminating excess verbiage, and using similar syntactic structures to express similar semantic ideas.

Law. The field of law is perhaps the main area of practical human affairs where the need for the precise use of language and complex reasoning is most in evidence. Preliminary applications of computer-based logic applied to rules and regulations support and extend the traditional role of logic in law. On the other hand, the complexities of legal reasoning present a healthy challenge not only to theories of logic but even to the natural exercise of common sense. The legal textbook "How to do things with rules" by Twining and Miers, for example, might equally be regarded as a text in applied logic as well as a challenge to artificial intelligence.

Mathematics. The most important lesson of mathematics is to teach us that what seems obvious is often false and that the "truth" can often be systematically determined by precise definition of terms, explicit articulation of hidden assumptions, and step by step reasoning. It also teaches us to look for and find generality where at first appearances there is only diversity. Unfortunately these hard lessons are normally taught in the context of an obscure subject matter that has application only in certain areas of science and engineering or in other areas of mathematics. Appropriate mathematical domains which might have greater relevance to everyday life include number theory, geometry and set theory, both in their informal and axiomatic presentations.

Philosophy. Philosophy is too vast and diverse a subject to do justice to everyone. In my opinion, however, some recent philosophy of science and epistemology is of direct relevance to the more effective acquisition, organisation and application of human knowledge and belief. My personal choice would include samples from Quine's "From a logical point of view", Goodman's "Fact, fiction and forecast" and Lakatos' collected works.

Formal Logic. At a minimum several alternative presentations of classical logic should be studied. Tarskian semantics and the completeness theorem should be covered; but also some elementary computability theory, Godel's incompleteness theorem, and formal metalogic should be included. The presentation of these subjects should be related to their practical manifestations in computing and artificial intelligence.

Practical work. In addition to the practical work relevant to the separate subject areas, special emphasis should be placed on the practical development of writing and computing skills.

It is a danger in a course as broad as this, that no subject might be covered in sufficient depth. For this reason a greater than usual emphasis should be placed on an individual project supported by relevant optional courses.