Interdisciplinarity: The role of Universities
A knowledge-oriented view

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Abstract

This short note summarizes the conclusions taken home from the Brainstorming Workshop held in Brussels on 20. January 2004 on the above topic of interdisciplinarity whereby the fundamental formal structures of knowledge as elaborated in Intellectics are taken as a guiding principle for viewing the topic and its aspects. It culminates in the suggestion to structure any discipline into a triple consisting of its hard disciplinary part, a general hard meta-disciplinary part and a soft integral part with appropriate consequences for curricula and funding schemes.

From a philosophical point of view the world in which we live is an integrated whole despite its rich diversity. For our human understanding, however, it is too complex to be studied in its entirety. For this reason disciplines evolved over the centuries in the history of the scientific enterprise.

A discipline is characterized above all by that part in the real world on which it focuses its attention: Physics on matter and forces, Chemistry on the phenomena related to the molecular structure of substances, Biology on living beings, Psychology on psychological phenomena, Intellectics (ie. Artificial Intelligence and Cognitive Science) on cognitive and mental processes modelling and explaining those phenomena. As a consequence of this disintegration of the phenomena in reality each discipline develops its own concepts and their relationships in terms of an ontology, its scientific methods of analysis and theory building, and its body of knowledge elaborated with these methods and described on the basis of those concepts.

The disciplinary structure of the scientific world offers so many advantages that there is no convincing reason for sacrificing it. It has proved extremely successful in many respects. For these reasons it will stay with us for many years to come.

However, there is a fault in the disciplinary view of the world from the very beginning exactly for the same reason that makes it so successful, namely the disintegrated view

of an integrated world. The knowledge, the way of its discovery, and the dissemination of knowledge (eg. by teaching) are necessarily one-sided and incomplete. This deficiency has always been felt, but the problems resulting from it are now aggravating to a serious extent for the following three reasons.

Never had knowledge so immediate and complex consequences for our daily lifes. Therefore the application of one-sided and incomplete knowledge may cause threats to humans and societies. The environmental problems, dangerous side-effects of drugs, and carcinogenic substances used in industry are just four out of many other examples.

The second reason lies in the importance of knowledge generation in the knowledge society and the fact that many discoveries are happening at the boundaries of disciplines. In strict disciplinary thinking they will therefore not happen, so that competitors with cross-disciplinary structures will have an advantage.

The third reason is the growing importance of meta-knowledge about knowledge and about the process of its discovery. Mathematics, Informatics (Computer Science) and Intellectics are the major disciplines producing precise meta-knowledge without which the wheel will be rediscovered a thousand times and, more importantly, often in vague and unreliable terms. For Mathematics and Informatics this role is widely accepted while that of Intellectics is still less well-known and thus deserves a few sentences of explanation.

The goal of Intellectics is the understanding of cognitive processes by artificially modelling them on computational devices. Knowledge obviously plays a fundamental role in human intelligence. The study of mechanisms for the representation and manipulation of knowledge therefore has always had an eminent place in the short history of Intellectics. Today the area of knowledge systems may be regarded as a rather mature subdiscipline of Intellectics. Tens of thousands of systems of this kind are in daily use. The largest system, CYC, comprises one and a half millions of knowledge facts from common sense knowledge. It is based on more than a hundred thousand atomic concepts structured as an ontology.

Knowledge is the basis for any discipline including Mathematics and Informatics. With its knowledge formalisms Intellectics is therefore *the* meta-discipline par excellence. It has the potential not only to support the scientific process of discovery in the hard sciences but also to transform the soft sciences like the humanities and social sciences into hard ones by the introduction of the knowledge technology as is argued in detail in the book [Bib03]. Those disciplines are slowly becoming aware of this potential and its threat to their roles. To put it in the words of one of the leading US psychologists, Ward Edwards from the University of California at Los Angeles, taken from [Edw98, S.416] where he refers to the Bayesian nets, one of Intellectics' knowledge tools:

> *... the decision-theoretic tools are for the most part from new subfields of artificial intelligence ... . Psychology as a science must decide whether it is or is not a part of ... . If it is, then psychologists have some catching up to do; artificial intelligence professionals know what ... .*

What he says about Psychology could analogously be said about many other disciplines including Pedagogics, Sociology, Political Sciences, or even Philosophy.

The perspectives of this development are the evolution of a universal ontology embracing the concepts from all disciplines and knowledge systems containing hundreds of millions of entries. Given the explosion of the amount of knowledge produced every year, the need for a systematic and machine supported handling of knowledge is getting more pressing by the day which includes much more than just the storage and retrieval of texts as considered in the area of so-called knowledge management. It would be the semantics represented by the inherent structure of such systems. This structure consists of clusters of logically related knowledge items which would then define areas or disciplines rather than the historically grown communities of our days. This realistic vision should guide our measures concerning interdisciplinarity in research and education. Three of those measures could be the following ones.

1. For all students and curricula from secondary schools through universities distinguish the *hard* science part from the *soft* one and teach them both in any subject whereby the hard part should always include basic knowledge from the three meta-sciences Mathematics, Informatics, and Intellectics and the soft part should essentially be the same for all students addressing the world in an integrated way (including meta-knowledge such as learning how to learn).

2. In addition to the traditional discipline-oriented research provide funding schemes which are problem-oriented whereby the problems address integral aspects of the real world, this way fostering interdisciplinary research.

3. Adapt the reward systems and the funding organizations to the knowledge-structure-oriented view described above.

Of course, this short note has covered only a small, yet basic aspect of the wide range of interdisciplinarity. For many other aspects the reader is referred to the literature such as [AS02, Boa04].

References

[AS02] Kaare Aagaard and Karen Siune, editors. *The design and delivery of inter- and pluri-disciplinary research – Proceedings from MUSCIPOLI Workshop Two*, Aarhus, 2002. The Danish Institute for Studies in Research and Research Policy.

[Bib03] Wolfgang Bibel. *Lehren vom Leben – Essays über Mensch und Gesellschaft.* Sozialwissenschaft. Deutscher Universitäts-Verlag, Wiesbaden, 2003.

[Boa04] European Union Research Advisory Board. Working Group (WG 8) on Interdisciplinarity in Research. Draft, January 2004.

[Edw98] Ward Edwards. Hailfinder – Tool for and experiences with Bayesian normative modeling. *American Psychologist*, 53(4):416–428, 1998.