

# Information Systems and Software Engineering Research and Education in Oulu Until the 1990s

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*Abstract:* This paper discusses the internationalization of software business in the Oulu region. Despite its small size, the region grew rapidly and very successfully into a global information and communication technology business center. The University of Oulu, which was the northernmost university in the world at the time of its establishment (1958) had a strong emphasis on engineering since its very beginning. Research on electronics was carried out since the early 1960s. Later, when the Department of Information Processing Science was founded in 1969, research on information systems and later also on software engineering was carried out. This paper discusses the role of the information systems and software engineering research for the business growth of the region. Special emphasis is put on understanding the role of system-theoretical and software development expertise for transferring research knowledge into practice.

*Keywords:* Information systems, software engineering, information processing science, Oulu, Finland, history

## 1. Introduction

The University of Oulu came into existence in 1958, at the time as the northernmost university in the world. The Department of Information Processing Science came into being in 1969 [17, 32]. The University of Oulu is a multidisciplinary university, which was successful in creating a base of innovations for local production and economy [30]. The yearly student intake at the department slowly rose from the first ten in 1972 to the level of twenty-five in 1985 [31]. This paper focuses on the role of system-theoretical and software-oriented research expertise behind the rapid and successful development of the business in the region. We describe the developments of information systems (IS) and software engineering (SE) research and study educational efforts in these areas.

Some of the authors of this paper are senior scholars at the Department of Information Processing Science at the University of Oulu with different scientific

backgrounds and paradigms of the field. They also have professional careers in the practice, being involved in many of the development steps under investigation.

## **2. Scientific Research Reaches International Level**

During the period of 1985 till 1990 there were relatively little international business activities going on with the software companies at the Oulu area. Company image building, venture funding as well as European R&D projects were still lying ahead. CCC Software Professionals, however, was an exception. Its international operations were started right after its founding in 1985 through delivering large software projects to Soviet Union and some also to Saudi Arabia. CCC was also to become the first Finnish partner in a Eureka R&D project. The Riskman<sup>1</sup> project was prepared from 1989 onwards through one of its sister companies in Athens.

Whereas the software business activities were still a few, the main thread of becoming more international in the region had taken place through scientific activities, which was quite natural as science by definition is international. The information systems research entered a new era during this time through producing high quality scientific publications. Studying these mature scientific publications, i.e. established journals and very high-quality conferences, during as well as before the period under investigation, is a key method to study the internationalization process in this article. Admittedly, the effect of scientific publications on practice sometimes occurs hand in hand with the scientific progress in the information and communication technology (ICT) field, but most often the progress follows several years.

Professor Pentti Kerola had previously studied information systems development with major emphasis on systems design and modeling, introducing the 'PSC systemeering model' [18, 20].<sup>2</sup> The motivation for this research had stemmed from practice, but it was, however, theoretically oriented. During 1979-1980 Kerola was a Visiting Researcher at three universities at the U.S., namely University of Michigan at Ann Arbor, Florida International University, and University of California at Irvine.

At the Department of Industrial Engineering at the University of Michigan, Kerola was involved with a pioneering research effort on software engineering, known as the ISDOS project<sup>3</sup> led by professor Daniel Teichrow. This project focused on defining the problem statement language (PSL) and its automated tool support. This research was mainly computer science oriented.

Research collaboration with Professor William Taggart at Florida International University had started a little bit earlier. Taggart was interested in the information systems architects' roles and the PSC systemeering model [36]. The joint work with Florida International University involved a softer theme, namely human information processing styles. Kerola's interest and enthusiasm on the human

<sup>1</sup> <http://www.eureka.be/inaction/AcShowProject.do?id=530>.

<sup>2</sup> PSC is an acronym for Pragmatic-Semantic-Constructive systems development approach.

<sup>3</sup> ISDOS is an acronym for Information System Design and Optimization System.

side of technology already had become evident ever since he started working at the Oulu area. In their joint work, Kerola and Taggart discussed the importance and challenges of self-evaluation for human information processing styles, the gathering and interpreting of data related to such styles, as well as the implications of this for human resource planning in systems development projects [22, 27].<sup>4</sup> Kerola became a recognized scholar in this field, appearing as a keynote speaker at key conferences [24].

Professor Peter Freeman, a software guru at the University of California at Irvine, invited Kerola to visit him. This visit had a strong influence in the future developments of information processing science (IPS) in the Oulu area. The collaboration with UC Irvine deepened the research interest on software engineering environments and processes. Kerola and Freeman jointly introduced the PSC systemeering model into the software engineering community and analyzed software life cycles in conjunction with this [21]. Later Freeman published a textbook on approaching software engineering holistically as a system and treating it as an organizational function carried out by humans [2]. This research collaboration also led to other researchers from Oulu visiting UC Irvine. The works of Freeman boosted the birth of two important scientific fields, namely systems analysis and software engineering, which led to multiple research efforts in systems analysis and design methodologies in the Oulu region.

Much of the original research work with software engineering environments and processes, end-users and ease of use occurred at the multidisciplinary and humanistic SYKE research project<sup>5</sup> during 1982 to 1985. The majority of the researchers from this project entered into business. On the other hand, based upon this line of research, Risto Nuutinen, Erkki Koskela, Juhani Iivari and Pentti Kerola analyzed and described the role of information systems architect in the information systems curricula [28].<sup>6</sup>

Building on top of the systemeering research, Juhani Iivari and Erkki Koskela published their research on systems and process modeling and software quality in *MIS Quarterly* in 1987 [9]. This landmark paper emphasized the levels of abstraction as a key construct for systems design and introduced the PICO model<sup>7</sup> for systems modeling and design. This model was later applied on the development of embedded systems at Technical Research Centre of Finland (VTT, *Valtion teknillinen tutkimuskeskus*) [7].<sup>8</sup> Juhani Iivari carried out with this line of research [8,11], analyzing and conceptualizing in parallel with Barry Boehm a new way of approaching software and systems development instead of the traditional waterfall model, namely the hierarchical spiral model [1, 13, 14]. This work has contributed to the birth and advances in object-oriented and agile systems development approaches.

<sup>4</sup> Myllykangas provides a deep and first-rate analysis of the IPS research carried out at the University of Oulu in 1973—2004.

<sup>5</sup> SYKE is an acronym for the Finnish words “Ihmiskeskeisen Systemointimetodiikan Kehittäminen”.

<sup>6</sup> See also [27], pp. 51-52.

<sup>7</sup> PICO is an acronym for Pragmatic-Input/Output-Constructive/Operational systems development approach.

<sup>8</sup> Also see [27], pp.49-50.

During the academic year of 1988-1989, Juhani Iivari visited Professor Heinz Klein at the State University of New York Binghamton as well as Professor Rudy Hirschheim who had just moved into the University of Houston. Iivari worked with Klein and Hirschheim on analyzing different information systems development approaches and methodologies. These research collaborations later evolved into multiple articles in top scientific journals.

The major information systems research topics that were tackled at Oulu, but which were still to grow in international cooperation included the role of activity theory and its applications to information systems research and development [25], organizational implementation [3, 4, 5, 6, 33], end-user satisfaction [10, 12, 34], as well as computer-aided software/systems engineering. The main international contacts within these took place through the Nordic IS community, in particular through the annual working seminar for researchers and doctoral students, known as Information systems Research seminar In Scandinavia. Pentti Kerola, Pertti Järvinen, and Eero Peltola had founded this IRIS conference series in 1978.

In sum, information systems research at the Oulu area had entered into a new era in the late 1970s or early 1980s via getting international. During the period of 1985 to 1990, the level of publications reached the level of high quality and stabilized. The main research activities in this research tradition were information systems development and software engineering environments and processes. Most of the research projects were funded by Tekes, nowadays known as Finnish Funding Agency for Technology and Innovation, or by Academy of Finland<sup>9</sup>. We should also note that teaching and education activities were built directly on top of the core competences produced through scientific research in the information system and software engineering fields, providing a textbook example from a successful university key function, i.e. transfer of knowledge from the academia into practice. Companies such as Mobira and CCC Software Professionals benefited greatly from the accumulated software and systems development competence, in particular related to conceptual modeling and software process modeling.

### 3. Curriculums and Knowledge Transfer in Higher Education

Veli-Pekka Leivo's M. A. thesis in general history [26] gives an excellent description and analysis about the educational activities at the IPS institute. In this section we focus on the most fundamental educational sub-areas of the institute: master (undergraduate) [19, 29] and doctoral (postgraduate) education [23] from the viewpoints of different interest groups in their activities of knowledge transfer. *Informatics* is by its nature a methodological discipline, bearing connections with many other sciences [15].

*technological disciplines*, primarily electronics and digital signal processing, on which research and development in information processing and communication technology relies

<sup>9</sup> <http://www.tekes.fi/eng/>; <http://www.aka.fi/en-gb/A/>.

*structural and cross-sectional disciplines*, including mathematics, statistics, general systems science and logic, which generate the formal general means, methods and theories required

*behavioral sciences and humanities*, including philosophy, psychology, neuroscience, history, social psychology and work science, which study individual and group behavior and knowledge, information and data on human activities

*economics, administration and the social sciences*, which are concerned with behavior and management of business and social organizations with the role and significance of information processing, including knowledge transfer, in these.

Organizationally the Department of Information Processing Science was a faculty-independent unit, directly under the board of Oulu University from the very beginning up to 1985. Then the board decided to separate computing services from the research and educational activities of informatics, with the purpose to clarify the organization of computing services. At the same time, they raised a sensitive problem: Which faculty would be the optimal place for IPS in the technologically modern university? The final decision and organizational selection was the Faculty of Science because of the traditional position in the other universities. It also was contradictory with the recommendation of the IPS Institute — preferring the Faculty of Technology.

During the years of late 1970s and early 1980s the Department of Information Processing Science, following the reform of the university degrees, designed and developed the master level degree program in information systems architect (ISA). The metaphorical title of the holistic working role was based on the information systems research. An ISA is a professional, who can design the strategies of information systems development in organizations together with different interest groups and manage the development using those strategies.

In the middle of 1980s, software engineering (SE) supplemented the master program. A SE is a professional, who can produce interactive and end-user-oriented (applicational) software and manage development projects.

The sub-areas and levels in which these professionals expected to operate appear in Figure 1; the total field partitions into three levels from the point of view of the utilization of information and data systems, with the inclusion of software systems.

ORGANIZATIONAL	LEVEL	“ ISA--ISA--ISA “	“SE “
USER	LEVEL	“ ISA--ISA “	“ SE--SE “
TECHNICAL	LEVEL	“ ISA “	“ SE--SE--SE “

Figure 1. Levels in which ISA and SE were expected to operate.

Both of the professional roles cover all three levels, but with a different focus and weight. The task of a professional at the organizational level is to define how information systems and computer/communication technology in general can be exploited to achieve the aims of particular organizations, while the task at the user level is to define information systems in such a way that those will serve day-to-day interests of the user optimally. One may see the task at the technical level as constructing software of high technical quality that conforms to the definitions and aims specified at the other levels.

The content of education and teaching in those curriculums fall into the following ten themes:

- professional orientation
- preparation for participation in the working community
- development of problem solving abilities
- introduction to scientific paradigms, different kinds of work and methods
- introduction to organizations, their main functions utilizing data systems, and industrial software production
- data management and organizational principles of data generation
- introduction to human behavior and informational activities
- computer hardware and software systems
- software systems, programming and programming technologies
- data systems, their life cycles, systems development methods and technologies.

The most fundamental core of education is in the themes 4 through 7. From the viewpoint of successful knowledge transfer between researchers and practitioners the special weight and focus occurs in the studies during the project work courses [35]. The total obligatory educational effort appears in the three stages:

*Foundations*: principles of project work and programming project in ‘labs’

*‘Real life’ effort*: practical teamwork and project seminar

*Research effort*: research teamwork and M.Sc. thesis seminar

Those stages began in 1972 and the same principal of implementation has continued into these days. Up to 1990s, over one hundred real-life projects were implemented at the department.

The programming project was a five study-week course implemented during the third study year in the fall and spring semesters. The aim was to integrate the knowledge from the preceding courses, especially courses on the principles of project work, software design, and programming. Usually in one semester five projects on the average were carried out. There was no charge for these projects. The estimated amount for student work was 200 hours/student with three to five students in a project. The younger students worked under the management of older students who were receiving extra credit from optional participation. Nearly all the projects were delivered to real customers in the surrounding community. Basically the requirement was that the specifications for the project should be “ready” when the projects began. This did not hold true in all cases and many

times the students had to work with developing or at least refining the specifications together with the customers.

The real-life project work was a six study-week course implemented during the fourth study year in the spring semester. The aim of the course was to integrate the knowledge from the preceding courses of the second stage. Usually eight to ten projects were carried out during one semester. The students worked about 250 hours/student and the staff from the department acted as project managers. The department charged the customers at the delivery of the project and compensated the students for their work.

In project seminars each group wrote a report where own selected experiences were compared to and evaluated with results reported in scientific publications. Each had to select one or two topics where to concentrate. The structure and style of the report was to follow that required in scientific papers.

The group presentations tried to be as effective as possible with the sharing of the experience. The seminars were moderated by the use of an opponent group, whose task was to support the dissemination by various ways, catalyzing discussions, and criticism. The students were encouraged to use innovative forms of interaction.

The diversified IS and SE research produced the feasible base to develop a holistic and highly interactive educational system at the institute. On the one hand, the ICT practice directed the different kinds of research interests, which on the other hand positively influenced on the selection of higher educational aims and contents. As the international review committee evaluated in 1990:

*"... the ideas emanating from the comparative research of IS Curriculums have been utilized in the design of the own curriculum... the teaching programme seemed to be a comprehensive, well-balanced IS Curriculum, covering theoretical as well as applied subjects."* (our condensation) [16]

In nation-wide doctoral education, the institute actively participated in the Finnish Doctoral Programs of Information Systems Research and Information Technology. Professor Pentti Kerola was the first coordinating professor in 1985-1986 for ISR doctoral education. Later during early 1990s, Professor Juhani Iivari had the same position.

The institute has been especially active and collaborative in the development of the IRIS conferences where the special focus has been in supporting higher studies of doctoral students. The same aim, but more local, has been in the KISS-effort, Kilpisjärvi IS symposiums. There, in the most creative natural environment, in the northernmost region of Finnish Lapland near the Norwegian border, young doctoral students and their international and Finnish mentors have since 1989 interacted especially with the purpose of refining the doctoral research plans.

The association of information processing students at the Department of Information Processing Science, Blanko, has existed since 1973 in order to create a social spirit among the students by offering recreational opportunities and organizing various educational events outside the degree program. Officially, Blanko had regular student positions in the committee of educational development in the institute.

The most significant annual event has been the Blanko conference series, where researchers as well as practitioners have presented newest information in the form of a general interest seminar about the research and educational experiences as well as practical industrial experiences of the field. The Association of Electronics Engineers and the Data Processing Association of the Northern Finland have been the contributing partners. During the 1980s, the Blanko conference series grew radically from the viewpoint of media exhibitions. Regrettably, the whole process of Blanko conference declined radically in the years of early 1990s during the severe economic recession and has only during the last five years reclaimed some of its former status. Still, the active student interaction with different business, communal and other organizations positively influenced on the good balance between the demand and supply of university level work force at the Oulu ICT area.

#### 4. Conclusion

The level of publications by the researchers of the Department of Information Processing Science reached the level of high quality and stabilized by the 1990s. The main topics were information systems development and software engineering processes and environments.

Teaching and education activities were built directly on top of the core competences produced through scientific research in the information system and software engineering fields. The diversified IS and SE research tracks produced a feasible base for developing a holistic and highly interactive educational system in the department. During this period, the ICT practice directed research interests and educational contents providing a textbook example from a successful university key function: *Transfer of knowledge from the academia into practice*. In the future work, the original contracts and project reports between the department and companies should be studied. It would also be worthwhile to take a closer look at the active student involvement with business, community and other organizations, which, in a positive way, greatly influenced the balance between the demand and supply of university degree work force at the Oulu ICT area.

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