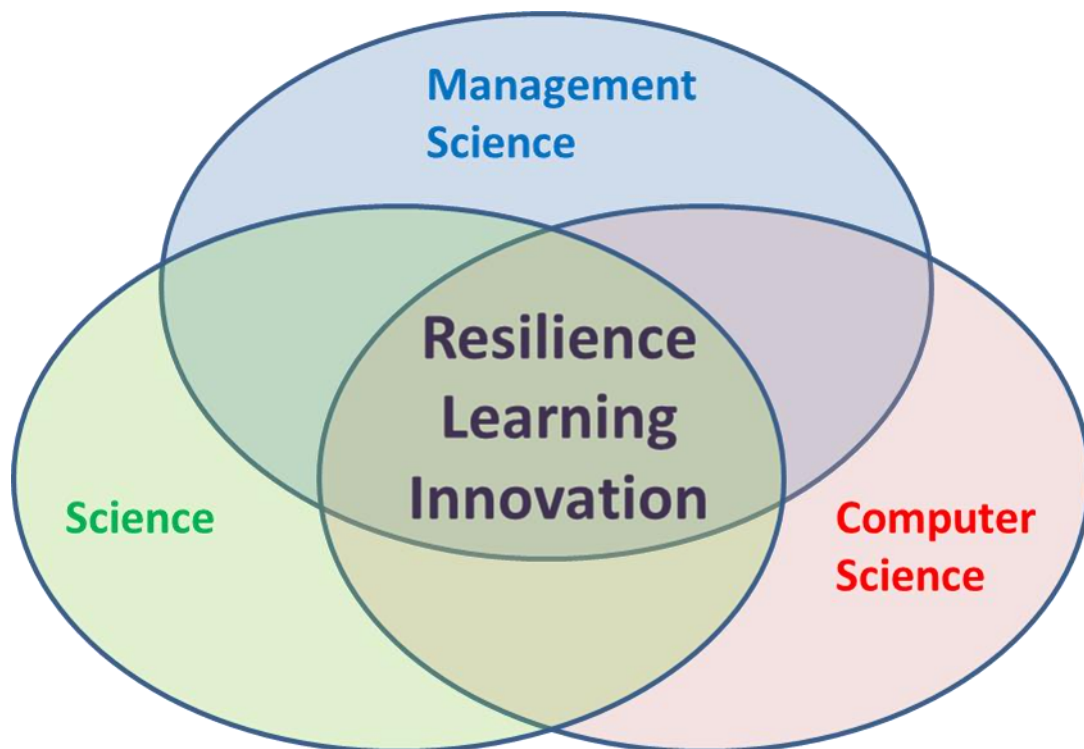# LEARNING AND INNOVATION
IN RESILIENT SYSTEMS

MST Research Program 2015-2020

18 Dec 2014

PREFACE

This document presents the research program of the Faculty of Management, Science and Technology (MST). It was prepared by the MST Research Committee (Carolien Kroeze, Marjolein Caniëls, Dave Huitema & Harald Vranken).

The program has been approved by the dean on 18 December 2015, and will be evaluated on a regular basis. After this approval, the program forms the basis for a discussion within the Faculty on societal issues that will form the focus of the research for the coming years.

1. INTRODUCTION

The mission of the Faculty of Management, Science and Technology is to create an appealing and lively research environment, leading to a high(er) research quality, productivity, and international visibility. The Faculty consists of seven departments. The research in these departments covers three scientific disciplines: Management Science, Natural Science and Computer Science (Annex 1). MST thus covers both natural and social sciences. The departments are responsible for four BSc programs and five MSc programs. We strive for close links between research and educational programs so that they can strengthen each other.

The MST research will be organized along a limited set of research programs. These programs serve as umbrellas for the research activities within the faculty and give direction and coherence to current and future research activities. The scientific staff of the faculty can collaborate around these programs and will be invited to propose activities, for instance by applying for PhD projects that enhance their expertise in relation to a particular program (e.g. learning for sustainability, innovation in environmental governance, or resilience of IT systems). We also aim for strengthening of existing collaboration with external partners, and seek for new external collaboration along the lines of this research program. Finally, we want our research to contribute to priority research questions as formulated in national and international research agendas, such as those of the European Commission, global research programs such Future Earth and the national programs (NWO, top-sectors, etc).

The programs are deliberately formulated in a multidisciplinary way, with the intention of cross fertilization between the various existing successful research initiatives within the faculty. The goals of the programs are (1) to present research within the faculty in a coherent way, (2) to build bridges between departments and encourage multidisciplinary research, (3) to guide future research directions within the faculty, and (4) enable participation in research assessments in the future. In line with these goals, faculty budgets will become available for funding research proposals that fit in and offer opportunities to expand the MST research programs.

This is a program for five years. However, it will be evaluated on a regular basis, and the first evaluation will be after one year.

2. SCIENTIFIC DISCIPLINES IN THE FACULTY

The research in the Faculty covers three scientific disciplines: Management Science, Science and Computer Science . These scientific disciplines form the core of the Faculty, and the BSc and MSc programs are rooted in these disciplines or collaborations between them.

Research in the *Management Sciences* as it takes place at the moment of writing of this texts is focused on divers aspects of learning and collaboration within and between organisations. Among others the following topics are studied: knowledge management, human resource management, finance, management of relations between organisations in the supply chain, regional economic development and sustainability. The involved disciplines are business administration, organizational science, public administration, accountancy, and economics. One binding factor in this is the concept of learning. Management scientists study how organisations learn and improve business processes, but also how they learn from market parties and their broader societal environment.

The *Natural Sciences* research mainly focus on environmental sustainability. In this field multiple disciplines are present (biology, ecology, physics, chemistry, physical geography, mathematics, pedagogics, etc.), but as a prelude to the envisaged multidisciplinary collaboration within MST a strong group of social scientists is also present (with backgrounds in public administration, governance, land use planning and science and technology studies). The current research by this group focuses on a wide array of topics including but not restricted to environmental modeling and scenario analysis, risk assessment, experimental work on the relation between environmental factors and living organisms, and innovations in environmental governance, and learning in environmental education. Empirically this groups focuses strongly on complex environmental issues (such as water and climate change), and much effort goes into better modeling and assessing risks, developing ways of better handling uncertainty, developing innovative curricula and investigating learning processes, and understanding how innovations in environmental governance emerge, spread and perform.

The current research in the *Computer Science* focuses on three lines: (i) Software technology for quality improvement and (ii) Software technology for teaching and learning (which both are addressed in the Department of Computer Science), and (iii) Sustainable integration (addressed in the Department of Information Science and Business Processes). This includes research on formal verification of functional and non-functional properties of software and computer systems, on security of software and computer systems, on tools to support teaching and learning of procedural skills by providing automated feedback, on didactics of computer science, and the design of business processes and information systems to support them in a sustainable way.

3. RESEARCH PROGRAMS

3.1 RESEARCH AIM

Resilience is the key guiding theme underlying the faculty's research program. Whilst resilience has often been associated with continued performance and stability of certain systems under stress (a conservative element), it can and will here be interpreted in a way that emphasizes the need for adaptation and even transformation (a proactive and change focused aspect). In this vein we argue that resilient systems are those that combine *exploration* and *exploitation* capacities. Exploration is needed to spot new developments, analyze and assess them so that the system can be amended if the need arises. Exploitation is about fine tuning the functionality of the system under the current conditions, so that effectiveness and efficiency gains are made. Both learning and innovation are deemed necessary for systems to become and remain resilient. In our understanding learning is about cognition, norms and about relations. It is aimed at better understanding phenomena that occur in the world, enhanced normative evaluation of such phenomena, and dealing with others by building greater levels of trust. In a way, learning is what makes systems ready for innovating, but innovation is also about organizational and political processes, and the agency embedded therein. Novel ideas and concepts do not develop, diffuse and impact the world just by themselves: they need to be stimulated. Particularly in the relation between innovation and learning MST can build upon the existing frontrunner position of the OU in the field of understanding and facilitating learning processes. MST can contribute to this through combine expertise from management science, science and computer science.

The overall aim of the MST research is, therefore, *to increase our understanding of the innovative and learning capacity of resilient systems, with a focus on (i) information and computer systems, (ii) organizational and management systems, and (iii) environmental systems.*

To achieve this overall aim, three research programs have been formulated, focusing on Resilience, Learning and Innovation.

The aim of the subprogram **Resilience** is to increase our understanding of the capacity of systems to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function.

The aim of the subprogram **Learning** is to improve our understanding of learning by individuals and organizations.

The aim of the subprogram **Innovation** to is to enhance our knowledge of how innovations emerge, diffuse and impact the world, and the role of agency therein.

3.2 RESEARCH PROGRAM: **RESILIENCE**

This research program focuses on resilience in systems, including social, natural and technical systems. Resilience is defined here as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function. It relates to sustainability, aiming at a desirable future state of systems that meet human needs in such a way that future generations may also have their needs met. Systems can be interpreted in the context of MST resilience research program as information or computer systems, environmental or biological systems, and organizational or management systems, as well as inter- or multidisciplinary systems.

Subprogram 1: Sustainability

Sustainability can be defined in many ways. Often, three dimensions of sustainability are considered: social equity, environmental quality and economic prosperity - people, planet, profit. In this subprogram we focus on all three, with special interest in environmental, social and corporate governance and sustainable chains.

The research may include the design of processes and systems contributing to a more sustainable world. Research on quality aspects of environmental system covers, for instance, environmental outlooks and interventions, and environmental risk assessment. The research on business processes and information systems may include, for instance green IT, semantic technology, and enterprise architecture. This subprogram also focuses on sustainability management and organization. Sustainability aspects of management covers, for instance, corporate responsibility, governance, supply chain management, sustainable organizations and HRM, sustainable business models for Open Educational Resources, or sustainable and social entrepreneurship.

Subprogram 2: Services and supply chains

Recently, the shift from product-based to service-oriented business models alias servitization spurs research in the development of professional services such as research on the Service Logic. In addition, new business models replace old ones, relating to for example 3D printing, recycling and reuse (closed loop chains) and circular economies. The expertise and innovation centre Business Intelligence & Smart Services (BISS) focusses on IT and more specific business intelligence solutions that add value to customers via customized services in procurement, marketing, sales, product design, finance and information technology. These (smart) services have implications for the configuration and management of supply chains as well.

This subprogram includes research on supply chains in which inter firm collaboration and competition takes place. The research is in line with the research on services and is founded in relationship management with a focus on (the management of) supplier and buyer relationships, including customers of customers and the suppliers of suppliers from a network perspective. Collaborating organizations are increasingly aware of the possibilities of joint data creation and data usage, e.g. based on smart services and business intelligence technologies. Main topics in the subprogram are integration of activities and processing, supplier development, influence strategies, compliance, outsourcing, collaboration, power and dependence. The research of the subprogram is at the heart of the Academic Centre of Excellence regional node which is certified by IPSERA (the International Purchasing and Supply Education and Research Association).

Subprogram 3: Trustworthy Systems

This subprogram concentrates on aspects of resilience that relate to the trustworthiness of software systems and information systems. The focus is on analysis and evaluation of aspects such as correctness and security. These aspects cover both functional properties, that define specific behavior or functions of a system, as well as non-functional properties, that define criteria that can be used to judge the operation of a system. The subprogram includes: research on formal verification of non-functional properties of software such as consumption of resources (energy, memory, processing time); formal verification of security properties such as non-inference in automotive systems; security of computer systems and information systems such as security of on-line banking and smart grids; and security of society such as defense against malicious infrastructures (botnets).

3.2 RESEARCH PROGRAM: **LEARNING**

This research theme addresses different aspects of learning, teaching and knowledge production. It covers a wide range of scales, ranging from the individual to the regional scale.

Subprogram 1. Teaching and Social Learning

This subprogram includes research on (online) learning, including automated feedback to students, virtual labs, and didactics. Research on *automated feedback* focuses on the development and evaluation of automated systems that provide feedback to students in an educational setting when working on assignments. Software technology is developed for teaching and learning. It includes the development of tools to support student learning of procedural skills, particularly in the field of mathematics, logic, and programming. In *virtual lab* environments students can work on practical assignments in computer security and computer networks. This research also covers automated feedback to support students when working on practical assignments in the virtual lab. This subprogram includes research on the *didactics* for teaching subjects in computer science, as well as on learning by students and the management of higher education.

Learning also takes place in networks of organizations that develop in collaboration information systems and IT applications. Such systems could on the one hand support and improve the various educational processes, and on the other hand automatically collect, analyse and feedback e-learning and assessment data for further improvement of the system. Another example are the 'smart services' provided by energy suppliers to energy users. Such energy management applications offer on the one hand local flexibility in energy use, and on the other hand collect data that can be used by the energy suppliers to offer additional services in advanced energy management.

Social learning is learning that takes place at a wider scale than individual learning through interaction among peers. It can be seen as a process of changes in peoples' perspectives on a problem and the possible solutions for that problem. Connected to social learning is the learning-action cycle which describes the intervention between learning and change and intervention. Social learning can be studied in many ways. This subprogram includes research on how social learning takes place and what factors affect it. It may, for instance, focus on the role of ICT and computer models in the social learning within groups.

Subprogram 2: Learning Organizations and Interorganizational Learning

Knowledge is a major creative force in current society. An organization's economic performance is no longer defined by what an organization collectively knows and can achieve at any given moment, but rather by its ability to learn. Organizational learning refers to the way in which organizations are skilled at creating and acquiring knowledge, and adapting their routines and business processes to reflect the uptake of new knowledge and insights. We study how organizational learning and knowledge management contributes to processes of continuous improvement and innovation within organizations, and how in turn this has an impact on social, ecological and economic performance of organizations. How can knowledgeable people be attracted to the firm and what role can be played by personal development within the organization? In this respect we address the acquisition of formal knowledge via education and training, and also the development of dynamic knowledge via informal learning processes.

Furthermore, we study in what way staff training (learning at the employee level) can contribute to better social, ecological and economic performance of the firm. In addition, we study how organizations learn by changing business processes and routines, and how these processes of change are managed and governed.

Research on interorganizational learning concentrates on different aspects of managing relations and learning in the supply chain, with a focus on learning from forward and backward linkages, including suppliers, customers, and service providers. A key objective is improving our insights about the factors that stimulate or hamper interorganizational learning and innovation, such as trust, power and dependency, and relational norms. Also collaboration in strategic alliances is subject of study. The behavioral aspect of management and accounting processes plays a role in this as well.

Subprogram 3: Learning Regions

Learning takes place in dynamic, interacting networks of organizations, in which universities, regional governmental institutes and firms are important actors. Network studies fit into this line of research, but also regional innovation system research. Studies typically concentrate on policy aspects of networks and systems of innovation. They focus on factors that stimulate and hamper learning processes that take place in the interaction between governmental institutes (universities, regional governmental institutes) and firms. The main insight is that networks of people and organizations are the driving power behind processes that fuel and maintain continuous learning, for instance via innovation and knowledge management. Studies in this line shed light on the way in which governmental institutions can stimulate learning within firms and regions with the aim of enhancing social, ecological and economic development - i.e., People, Planet, Profit dimensions of sustainable development.

3.3 RESEARCH PROGRAM: **INNOVATION**

This research program aims to enhance our knowledge of how innovations emerge, diffuse and impact the world, and the role of agency therein. Innovation is an attractive meso-level term, for which no single unified theory has developed as of yet. In addition, various different understandings of the concept exist side-by-side. Indeed the term innovation can refer to invention, to diffusion and to impacts, as indicated by the innovation triangle (Fig. 1).
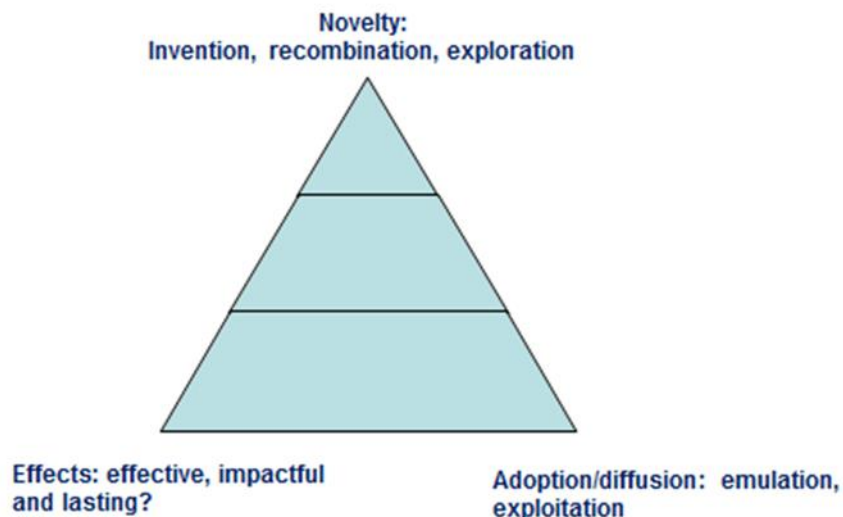

Figure 1: The innovation triangle (Jordan and Huitema, 2014).

Here we see the fact that various different ways of approaching innovations exist as a strength, as each offers different possible avenues for further research. It is important however to express that we will approach innovations from a functional perspective: they should help individuals, organizations and societies to better attain their goals, or enhance their performance in other ways. This implies a critical perspective, as innovations often imply questions about the current goals of organizations and entrepreneurship, and whether these should be changed.

The MST program on innovation relates to the other research programs (resilience and learning) by positing that innovations should help address societal problems. Topically, this research program studies innovations in organizations (e.g. human resource management and other business processes), the role of IT technologies in innovation, IT governance (data management, governance and health care; business intelligence and the role of social media), and environmental governance (policy innovations such as public-private partnerships, policy entrepreneurs, and policy learning).

Subprogram 1: Innovative Systems

The first meaning of the term innovation that we shall focus on refers to absolute novelty (worldwide new developments), or *invention*. Under the header of invention, various issues can be addressed. If, for reasons of convenience, we take a systems approach, it becomes clear that some systems (read: companies, governments, organizations, online networked knowledge systems, information systems, or ecosystems) are *more inventive than others.* Study will be made

of why this is the case. Existing research points to the importance of the presence of entrepreneurs and entrepreneurial behavior, but also to the influence of diversity, polycentricism, and shadow networks, as well as experimentation. In this subprogram study will be made of the role of policy entrepreneurs in environmental governance, the role of public-private partnerships and civil society groups in developing new solutions and interventions for environmental problems, and regional experimentation with novel environmental solutions. In addition, research will take place on the innovation of information systems covers the modelling of business rules, the design of correct and flexible information systems, governance and the use of business intelligence to support business processes and smart services.

Subprogram 2: Diffusion of Innovations

The term innovation is also often used to refer to the speed with which and the extent to which new approaches diffuse around the world. Concepts such as lesson drawing, adoption, post adoption dynamics, and international fora for exchange are deemed important for the spreading of innovations across the globe. Current studies point to the role of affinity in this respect, that is, the fact that organizations cluster and look to certain other organizations for leadership on the direction that innovation will take.. Under this subprogram, study will also be made of the role of scientists in the diffusion of novel environmental policy concepts (such as Corporate Social Responsibility, River Basin Organizations, and Emission Trading Systems) , but also of the way companies influence each other in terms of environmental behavior within supply chains and by changing their own business models. Organizations increasingly collaborate in so-called value networks, on the co-creation of new and complex (compound) services for customers and business systems. These networks require innovative (joint) information systems e.g. regarding flexibility, interoperability and data security

Subprogram 3: Impact of Innovations – performance and evaluation

The third meaning is about the *impact* that the innovation has created in a societal sense; here the notion of performance and evaluation is key. Evaluation can be done at various levels. One possibility is evaluation against the stated goals of the innovation, but it is probably more important that such evaluation takes place from the perspective of broader societal goals (reflexive evaluation). This reflexive evaluation can refer to qualitative and/or quantitative dimensions as reflected by different methodological perspectives used in this subprogram. The science organizations and knowledge production will be studied and evaluated. Under this subprogram research will be done on the impact of finance and financial accounting innovations. Furthermore, research will be done on the performance of business, the evaluation of environmental policy, but also on the impact of new IT technologies on business process management, for example the impact of outsourcing of processes across value networks or data analytics.

3.4 CROSS-CUTTING THEMES

Figure 2 indicates how the scientific disciplines (Management science, Science and Computer Science) contribute to the research in different subprograms. Cross-cutting issues can be found in every subprogram.

MST Research focuses on issues of high societal relevance. To this end, the MST Research Committee will every year prioritize research themes within and across the three research programs. These themes will encompass research activities that can compete for MST funding. All research aims to increase our understanding of the innovative and learning capacity of resilient systems.

Examples of priority themes are:

1. Health care
2. Sustainable management of organizations and supply chain management
3. The energy/water/food nexus
4. Business intelligence and smart services
5. Smart and sustainable cities and regions
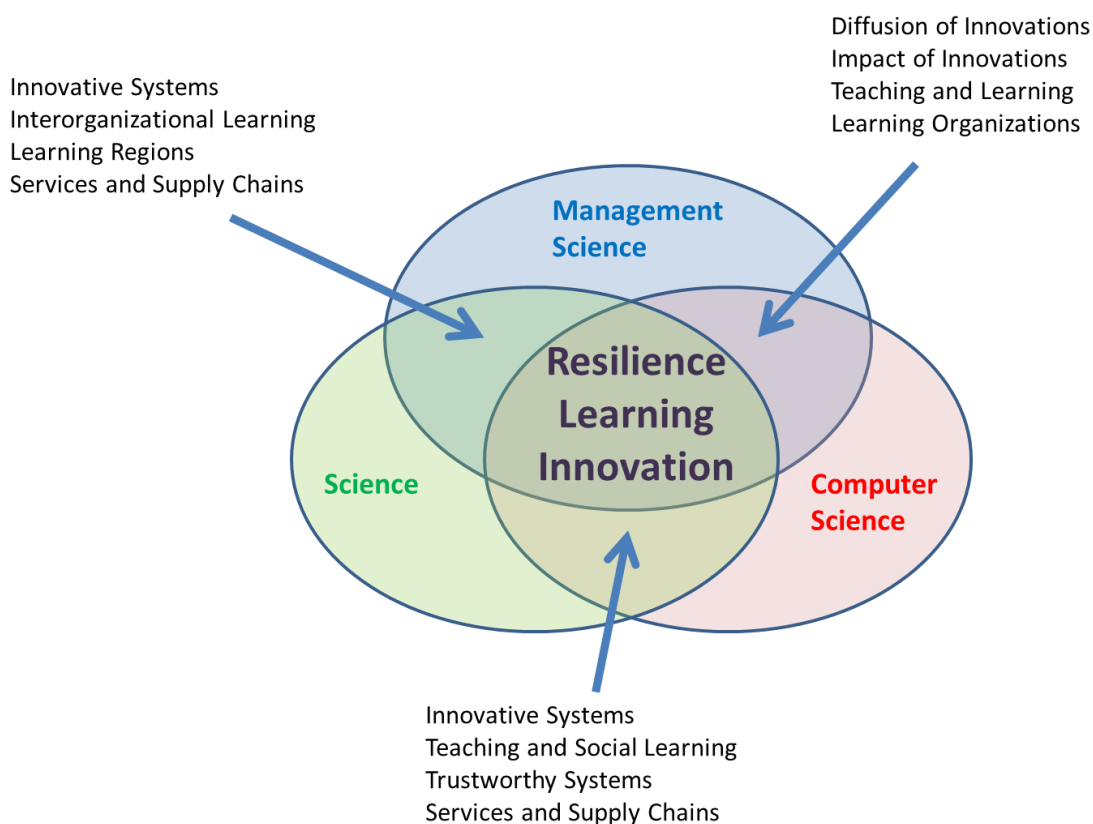6. Management of higher education

Figure 2. Overview of the MST Research Program on Resilience, Learning and Innovation. The blue arrows give some examples of the multi-disciplinarity of the subprograms.

ANNEX 1: MST RESEARCH: DISCIPLINES, DEPARTMENTS, AND PROGRAMS

SCIENTIFIC DISCIPLINES:

- Management science
- Natural science
- Computer science

DEPARTMENTS

- Strategy and General Management
- Marketing and Supply Chain Management
- Organization
- Governance, Finance and Control
- Science
- Computer Science
- Information Science and Business Processes

RESEARCH PROGRAMS

- Resilience
- Learning
- Innovation