Research Activities at the University of Siegen

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1 Introduction

The University of Siegen is a research-oriented university with the goal of promoting excellent, internationally recognized research. As the driving force and mirror of developments in society as a whole, universities have a duty to contribute to the solution of current and future societal challenges and to transfer scientific insights to society. The guiding principle of the University of Siegen "Shaping a humane future" characterizes the mission and actions in research, teaching and transfer. Two of the major challenges, namely the comprehensive digitalization of all areas of life and the transformation towards a sustainable economy and society, intersect all research areas.

Thereby the University of Siegen is committed to the principles of Good Scientific Practice, to the respect of different cultures across disciplines and research directions, the trusting and open handling of scientific discourse and the recognition and appreciation of the achievements of researchers. Its goal is to maintain the existing variety of research topics and to further develop a balanced relationship between individual research projects and collaborative research projects.

2 The Research Landscape

The University of Siegen focuses on the promotion and expansion of the already existing internationally visible profile areas and research foci in order to further sharpen the universities research profile. Those **profile areas** are characterized by long-time strengths in fundamental research. While already established through proven past merits at the University of Siegen, they are to be strengthened and expanded for future research. The profile areas of the University of Siegen represent thematically focused, partly interdisciplinary oriented research foci that address the major scientific and societal challenges. The four profile areas

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are (1) Media & Culture, (2) Education & Social Society, (3) Sensorics & Visual Computing and (4) Matter & Quantum Systems

The University of Siegen supports research activities that pick up on pioneering trends and take part in developing and shaping new research areas. On the one hand, these **areas of competence** are research-active areas that are either in the process of being established or redefined. These are being further expanded and supported by the university in order to lay the foundation for innovative research clusters and coordinated, large-scale research alliances. On the other hand, these areas also include research groups that conduct applied and practice-oriented research with a focus on transfer. The three areas of competence are: (1) Smart Work & Smart Everyday, (2) Nanotechnology & New Materials and (3) Health Care & Gerontology.

3 Outstanding Research

The traditionally strong profile area **Media & Culture** investigates practices in media and culture of contemporary societies and the respective social and societal effects. Currently, the research concentrates on the ubiquity of media practices and the transformation of society through new methods to measure attention and develops new methodological approaches and theories. New sensor-supported or autonomously acting media as well as the associated data practices determined by algorithms or smart devices are shaping the current transformation of our society from a digital network society to a data society. Algorithms and automation are also the driving force regarding the determination of popularity values (likes, usage, sales, etc.) in rankings of all kinds, with serious consequences for the social distribution of attention and its legitimation in art and literature, science and politics, religion and education. The associated fundamental social and cultural change not only affects our perceptions and communication structures, but also significantly influences our social life and our cultural and political identity. The transdisciplinary research of this area analyses these developments and combines cultural studies, literature and media studies, linguistics and social sciences, history, educational sciences, psychology, economics and computer science. With currently two Collaborative Research Centres, the University of Siegen is one of the internationally outstanding locations in the field of praxeologically oriented media and cultural studies.

The profile area **Education & Social Society** focuses on social integration as a challenge for an increasingly diverse and dynamically changing society. Education, social participation, migration, and social systems are topics that deal with the challenges of an inclusive society, which is characterized by diversity and mobility. Intensive cooperation in inter- and transdisciplinary collaborative research projects among the disciplines of social work, special education, and social science, are dedicated to researching the welfare state and its governance structures as well as the facilitation of social participation from a wide variety of perspectives: Specifically, both intended and unintended consequences of social assistance are looked at from the perspective of the persons addressed. Another research network is working on how migration changes institutions and when do institutions mobilize or immobilize; this network joins migration research, sociological and political research on institutions by taking sociological, ethnological, and political science perspectives into account.

The profile area **Sensorics & Visual Computing** is centred around trendsetting sensor developments and nanotechnological research. The close interdisciplinary cooperation of groups working on fundamental research in physics and physical chemistry, microelectronic sensor development and data processing in information technology is very unique at the University of Siegen. One main focus is the development of intelligent sensor systems. Using new methods of machine learning allows us a simultaneous integration of hardware and information processing. This highly interdisciplinary approach and the close cooperation between the disciplines opens up a wide range of advantages in terms of data efficiency, privacy protection and the ubiquitous integrability of future sensor systems. With its focus on "Smart Sensing", the Center for Sensor Systems (ZESS) forms the condensation point of this research. Another research focus includes biomolecular assisted sensing, personalized digital medicine or sensor-based systems and materials for diagnostics, which are developed in the Research Center of Micro and Nanochemistry and (Bio)Technology (Cμ), using methods of micro- and nanochemistry and microelectronic sensor development. This research area is also characterized by a high degree of interdisciplinarity, bringing together researchers working on topics like nanotechnological integration, ubiquitous sensing, intelligent autonomous recognition and classification methods. The development of integrated electrotechnical and chemical sensors, which is relevant for both focal areas, is supported by establishing the Interdisciplinary Research Center for Nanoanalytics, Nanochemistry and Cyber-physical Sensor Technologies (INCYTE).

The profile area **Matter & Quantum Systems** comprises fundamental research in the fields of elementary particle physics and quantum optics. This internationally visible area of the University of Siegen carries out its research in theoretical and experimental physics to study matter and quantum information technology in coordinated collaborative research projects. Theoretical research in elementary particle physics deals with conceptual aspects of quantum field theory, with the development of mathematical methods for performing precise calculations within the framework of the Standard Model of particle physics and its possible extensions. The focus lies on heavy quark flavours, quantum chromodynamics, Higgs physics, and new models beyond the Standard Model. The development of novel detectors and the analysis of data from two large experiments, the ATLAS experiment at the Large Hadron Collider (LHC) and the Pierre Auger Observatory, are the centre of experimental research activities in particle physics. The research is embedded in internationally relevant collaborations, such as CERN or DESY. The fields of quantum optics and quantum information theory form another research area. Research on an innovative quantum core module as the basic building block of a future quantum computer is being pursued in collaboration with other universities and industry collaborations.

4 From Research to Innovation

In **Smart Work & Smart Everyday**, the focus is on the design of successful smart production, process optimization for SMEs based on artificial intelligence, and smart applications for everyday life. Particular attention is paid to the consequences and opportunities of digitality for consumers and regional economy, especially for small and medium-sized enterprises. The transfer between science and regional SMEs takes place in

joint projects and competence centres, in which the realization of smart production or the research of innovative tool concepts and components are tested. A key question of this competence area is the research and configuration of human-machine interaction in both working and everyday environment. This includes smart applications in sustainability and resource optimization, but also in health care and assistance robotics for the aging society. The central question is how technology can be designed to be accepted, used and experienced as meaningful by humans.

The development of highly efficient materials and manufacturing processes that minimize resource consumption, maximize performance parameters and being ecologically sustainable is the focus of the **Nanotechnology & New Materials** competence area. Areas of work also include materials that can endure infinite duty cycles, nanostructured composites, smart multifunctional materials, micro- and nanostructured (bio)materials, monitoring systems for structural integrity, and composite materials for lightweight automotive manufacturing. These research activities are primarily located at the Research Center of Micro and Nanochemistry and (Bio)Technology (Cμ), and at the Multidiscipilary Center for Innovative Materials at the University of Siegen. The three central research topics, materials science, sensor development and cross-scale characterization are to be brought together by establishing the new the Interdisciplinary Research Center for Nanoanalytics, Nanochemistry and Cyber-physical Sensor Technologies (INCYTE). This will form the infrastructural base for future-oriented, interdisciplinary research and development of new materials and sensors at the University of Siegen.

The focus of the competence area **Health Care & Gerontology** is an application-oriented approach to individualized, evidence-based, and integrated health care. Innovative care models for rural regions with limited access to the healthcare system (especially in the context of the model project "Medicine Rethink®" and the Digital Model Region Health Dreiländereck DMGD) are developed. The central research topics are biomedical sensor technology, mobile health information technology or digital assistance systems. A special focus is laid on aging research and IT applications for the aging society. In the Gerontology Network Siegen (GeNeSi) together with partners from health, business, politics and care, the requirements for good and self-determined aging are analysed and new concepts are developed in interdisciplinary research projects.

5 Involvement of Students

In Germany doctoral studies are in general not considered as a third cycle of an academic education, but rather as a first employment. Thus, this part of the training of young scientists is usually seen as research work, however, with still some supervision. As a consequence, doctoral students are naturally involved in the current research work, providing an excellent "training on the job".

The University of Siegen considers the creation of excellent career conditions for the qualification and profiling of young academics an important matter. The University of Siegen offers an optimal environment for the development of individual academic career paths at all career levels, starting with master's students, doctoral students, and postdoctoral researchers

to junior professorships. The graduate center "House of Young Talents" was set up to provide intensive and interdisciplinary advice to young researchers.

In addition to support and counselling offers in the qualification levels of master's students and doctoral students, postdoctoral researchers in particular are to be shown and paved the way to scientific independence as early as possible. Young scientists with a doctorate and with visible potential are increasingly funded with the aim of supporting them in their development into research personalities and to optimally accompany them on their further career path. The independent implementation of research projects and the acquisition of third-party funds is an important component here. The Research Funding department supports and coaches young scientists in a targeted and individual manner with the initial application and, together with the graduate center "House of Young Talents", offers workshops and information events on third-party funding.

6 The vision of ATHENA research-based cooperation

Our society is experiencing sudden changes in the way people and institutions produce and manage value. These changes are in part due to the growing ease with which people can collaborate nowadays. Many successful cases of peer-to-peer models of organization arise and assume leading positions in world economy. People are evolving and interacting inside heterogeneous teams composed by members from many different cultural groups and with distinct skills and backgrounds.

Modern economy and society being highly dependent on technology requires complex problem solving and communication skills in technical subjects. In such a demanding and culturally diverse environment as the professional world is today, it is essential to promote the development of team-work and communication skills at an international and intercultural level.

Presently, there is an increasing need for the establishment of international and multidisciplinary teams. These teams, either spontaneously or explicitly generated, are capable of conceiving and developing successful products to be distributed worldwide. Therefore, we consider being of extreme importance to start promoting this type of work as early as possible – even in students' academic activities. Leading future engineers at an early stage of their higher education to be involved in an academic multinational project where they will need to interact and communicate at distance with their team and work together to fulfil a common target, will certainly be challenging and enriching both for students and teachers as well as researchers involved. Furthermore, it will provide all with the communication and cooperation skills essential to survive in the international world market.

An alliance of different Universities as the European University ATHENA provides an ideal platform for students, teachers and researchers to cooperate in education as well as in research projects, that generate relevant outputs to the community.

The starting point for establishing the core group of ATHENA has been the *Multinational Undergraduate Team Work* project (MUTW), in which students from different countries have been collaborating in small research projects. This activity has now been successfully continued since more than 10 years.

The cooperation of these Universities has been continued by several Erasmus plus research projects establishing an innovative infrastructure to promote the communication between deaf and non-deaf as well as among international deaf students.

The expansion of the core group with three additional universities created the ATHENA Alliance. The mission of ATHENA is to become a global hub for excellence and inclusion, intensifying high-end knowledge production, radically improving access and sharing results in more innovative ways.