

School of Industrial Engineering and Management, KTH

Development plan 2018-2023

1 Introduction to our plan

The UN has identified 17 sustainable development goals¹, many of which relate to industrial engineering systems and their management and thus particularly to the ITM school. Of these goals, we consider the action to combat climate change as the most acute, a chance to help tackle the underlying threat to life on the planet as we know it. Major impacts on climate change include the provisioning and use of energy in domains such as manufacturing, transportation and smart cities, and the negative effects of the currently dominant throw-away society. Another UN goal, in some ways closely related, that we are well positioned to address is that of ensuring sustainable consumption and production patterns. These challenges constitute the background of the ITM vision for the coming six years.

The sustainable future – ours to create!

The vision of our school is to be a preferred partner – nationally and internationally – for students, faculty, industry and society in attaining an ecologically balanced, effective and dynamic industry by focusing on the holistic nature of the mentioned challenges, encompassing: IT and control systems, circular economic principles, new materials & processes, digital transformation, product innovation, smart energy systems, life-cycle sustainability, fintech development, educational quality and societal interactions.

Our **main mission** is to lead the transition towards a zero-emission, adaptable industry for a sustainable society characterized by new product and service designs, new materials, new business models, sustainable energy systems, recycling, reuse and remanufacture.

Each year, 10% of all new MSc engineers in Sweden graduate from the ITM School at KTH. These graduates constitute our most direct and powerful impact on society. Statistics on our doctoral graduations also demonstrates a large impact potential. No other Swedish educational establishment has such a large opportunity for impact through industrial engineering. With this comes a large responsibility to ensure that our graduates possess the right knowledge, skills and capabilities for a sustainable future. Our School takes this very seriously and is determined to further improve education quality and continue to adapt to the needs of a sustainable future. Our overall goal is that our graduates – on all levels – should be leaders of the much needed societal change. Our focus is thus: *Transition of the manufacturing, energy and transport sectors to a sustainable and climate-gas neutral future.*

This remarkable educational responsibility calls for a substantial increase and strategic adaptation of our research. This is particularly important since ITM has a substantially lower ratio between faculty funds for research and funds for education, compared to the KTH average. The School argues that this imbalance must be corrected over the period of this development plan, not only to enable us to live up to our educational obligation but also to meet the KTH requirements on scientific excellence and impact on society. To strengthen the impact of our education, the foreseen increase of the research base in engineering subjects is timely complemented by the fact that, since January 2018, the Department of Learning belongs to the ITM School. This gives us a strong base in research and development on the pedagogical side which corresponds well with our commitment to educational quality and content. In the longer term, the newly expanded ITM School further contributes to society within the STEM² area by providing leading teacher education to secure learning in future generations.

Our department structure has the disciplinary breadth to encompass research and education for complete value chains, product and system life cycles and related services. This broad coverage is both a key feature and a necessity to attack the huge environmental challenges ahead of us. In addition, we also have a responsibility to foster and increase interdisciplinary and cross-sectoral research, including collaboration with other players in society. An important stepping stone towards realising this is the

¹ <http://www.un.org/sustainabledevelopment/sustainable-development-goals/>

² Science, Technology, Engineering and Mathematics

Innovation Arena project which will run during 2018-2020. The redesign and reconstruction of our premises on Campus Valhallavägen constitutes the largest infrastructure development ever made by the ITM School, alongside the 2016-17 establishment of the new Campus in Södertälje.

The main chapters of this document outline how we intend to develop our research and its environment, and all levels of our education. *Innovation and entrepreneurship*, and *digitalization* have been identified as the key enablers to reach our goals – this holds true for education, for research and for impact on society. They are therefore briefly introduced below and will reappear with specifics in each of the following chapters.

Yearly action plans. It is the responsibility of the ITM management team (heads of departments, GA, FA, head and vice head of School) to plan for implementation of the vision, mission and goals set out in the current six years ITM Development Plan. This will be done through yearly action plans formulated through a process of prioritization in time and allocation of necessary resources. The School aims to establish a systematic way of monitoring how well we are developing in relation to the six year plan using, for example, concepts such as KPIs and balanced scorecards where it will be important to select criteria which lead us in agreed directions.

1.1 Digitalization

To maintain leadership in industrial engineering, excellence in applying and developing digitalization is a necessity. Digitalization, where digital technique is involved in changing the way the business is done, is a transformation where KTH has an ideal position to be a leader. The intensity of digitalization in today's society and the President's focus on the issue calls for a strategic approach of tackling digitalization at ITM. The assumption is that digitalization not only will affect KTH, and ITM, broadly the coming years, but also constitute research and education content. ITM will put strong focus on where the need for change is, rather than jumping into solutions created by technological possibilities. The following areas of activities will be part of our agenda for the coming four years:

- The rapid digital transformation of society and industry affects the content of ITM's research and education. In order to continue to be a leading and relevant academic environment closely linked to the outside world's development, ITM will make strategic investments and priorities in research and education content on digital transformation within the school's various areas.
- The research and education support is an area where digitalization has a potential to decrease costs and increase quality. While ITM is not in charge of the systems³, ITM:s researchers and teachers have the expert knowledge on the needs. Hence, the management of ITM needs to identify the most urgent steps and advocate initiatives to solve them on the central university level. Being successful here, ITM will need to adopt its routines to systems provided centrally. This implies a tighter organizational connection.
- During 2018 – 2023 ITM will initiate a process for digitalization targeting main goals of KTH; education, research and impact. The staff representing the managerial layers in the organisation will be responsible for making sure that the change work in their respective parts of the organization is carried out. The work will be coordinated by the School management team.

In addition to these actions, ITM realises the potential in students graduating from ITM's various programs. Properly utilized, this potential means that students can act as change agents to push for digitalization towards a more sustainable industry and society.

1.2 Innovation and entrepreneurship

Defined as activities aiming at the creation of novel and valuable products, services, processes and businesses, *innovation and entrepreneurship* (I&E) is a key theme for ITM. Systematic knowledge about I&E allows leveraging technical expertise to create social, environmental and economic value. This theme therefore has a natural integrating role for teaching and research activities within the School, and plays an important part in the School's impact in industry and society at large. The following objectives, to be fully realized at the end of the development plan period, will guide the School's strategic development of activities within I&E:

³ I.e. Prisma, Agresso, HR+, KTH RES, LADOK*, Canvas etc.

- ITM constitutes an environment for I&E research and education that is internationally recognized and attractive for students, researchers and external stakeholders.
- ITM expertise allows KTH to offer all its students cutting edge knowledge of technology-based I&E processes, both through basic taught modules available across engineering educations and through opportunities to graduate with a specialization in I&E.
- ITM students are offered rich opportunities to develop ideas and innovative projects beyond their coursework.

These objectives are to be achieved by 1) consolidating existing teaching, research and supporting activities in the area; 2) further strengthening the area throughout the development plan period; 3) strategic efforts which enable synergies between activities and resources, and which increase the visibility of the environment; and 4) leveraging the local opportunities for I&E support in the wider Stockholm environment.

2 Academic environment

2.1 Leadership in Industrial engineering

Our academic environment should reflect *leadership in industrial engineering* and build upon conscious integration within the knowledge triangle of research, education and innovation. It should be supported by up-to-date premises and state-of-the-art infrastructure to facilitate research, education, innovation, entrepreneurship and student engagement.

2.2 Means to reach the leadership

Strengthened and new subject areas

ITM investigations as well as KTH-central studies of the five KTH Schools show that ITM resources are imbalanced in the sense that research/research education funding (and hence size of the faculty) compared to undergraduate/graduate education funding is remarkably small in relation to the KTH average. ITM has also concluded that this imbalance has a multiplicative effect since it limits the possibilities of attracting external funds. ITM envisions a gradual increase in funding for research and research education for investments in the areas listed below, addressing the societal challenges described in Chapter 1 of this plan.

- Industrial transformation through digitalization, renewable energy and circular economy
- Integrated mechanics, components and materials design, including additive manufacturing
- Innovation and entrepreneurship ecosystems and infrastructure
- Sustainable energy systems, infrastructure and business
- Dedicated support to units with a particular imbalance between faculty funds for research and funding from education and external projects

Each of these is initially outlined in a one page document including area description and resource needs over the coming six year period. Together with this Development Plan, these five documents form the ITM proposal to KTH for our activities from 2019 and onwards.

Research intelligence and communication

The anticipated increase in research and research education funding must be followed by efficient processes for attracting external research funding, for equipment procurement and for communication of activities and results, from both education and research. We use the notion of *research intelligence* to raise the importance of this aspect. Over the past few years, ITM has made various efforts with similar ambitions (research funding initiative, research road mapping initiative) and there are results that can be re-used. To be successful on the School level will require effective and efficient collaboration with KTH general research and legal support functions. In accordance with the

assignment from the 2018 KTH Activity Plan, ITM will propose - and subsequently contribute to the development and operation of - a new KTH-platform in “Production”. (“Production” is here put in quotation marks because the naming of this platform should be further discussed.) Concurrently and in a coordinated manner, ITM will also contribute to the development and operation of a restructured KTH-platform in ICT. We see clear synergies between the two platform initiatives.

Premises and infrastructure

The ITM School is spread over multiple locations across two different campuses which require additional effort and development initiatives when it comes to our premises and infrastructure. The KTH Södertälje Campus hosting the Department of Sustainable Production Development is brand new and developing rapidly. As such, it will require further investment in research and education infrastructure over the coming six year period. In contrast, the ITM-part of the KTH Valhallavägen Campus is these days largely characterized by lack of maintenance and need for modernization.

The ITM Innovation Arena: The physical environment is a critical mechanism for both efficiency and innovation in working life. Thus appropriate accommodation with up-to-date experimental infrastructure, laboratories and workshops is critical to academic success, as are the education facilities and work spaces of all employees and students. In a joint effort ITM is developing an Innovation Arena that will specifically facilitate meetings, experimentation and visualization in order to strengthen our collaboration within and beyond the School, and secure the impact of our teaching and research. The Arena should utilize digital tools for distance meetings and learning, and strive for the most efficient use of the physical resources. Every ITM building on the Valhallavägen Campus will be developed in accordance with these aims, and in particular the area of Brinellvägen 68-87 will go through a major redesign and restoration.

Innovation eco-system

KTH is situated in the Stockholm-Mälardalen region (Stockholm, Uppsala, Västmanland, Södermanland). The industry in this region stands for close to 35% (2017⁴) of Swedish goods export value, and is the “no doubt” leading industrial region in Sweden. Also in the area of innovation and entrepreneurship, Stockholm and the Stockholm region is outstanding, in both national and international perspectives. Over \$1,4 billion SEK was invested in Stockholm-based tech companies in 2016⁵. This amount is more than half of the total amount invested in the entire Nordics. Also, in Stockholm, 18% (2011⁶) of the workforce work in high-tech related jobs. This is the highest share compared to any other city in Europe. By exercising science and innovation leadership in industrial engineering on the level of European competitiveness, KTH has a strategic role to strengthen this region and to catalyse the transfer of its industry to a circular and sustainable system.

The ITM Departments have and should continue to have extensive cooperation with industry and other stakeholders in society, both nationally and internationally. However, as is apparent from the previous paragraph there are also specific arguments for a certain focus on the Stockholm-Mälardalen region. ITM will therefore initiate, find forms and identify stakeholders for a strong, innovative and vibrant industrial engineering eco-system in the Stockholm-Mälardalen area. This should build on the knowledge triangle of industry, research and education and utilize a triple-helix approach. The initiative should lead to the region and its industrial sector becoming recognized at the European level as an outstanding innovation and entrepreneurship eco-system. ITM will also lead the branding of KTH as a key contributor to addressing the societal challenge posed by the current non-sustainability of the manufacturing industry. A KTH-wide research platform in “Production” and the ITM Innovation Arena will be important enablers for this and for supporting the innovation eco-system.

Working environment

KTH has a *code of conduct* and ITM has defined its *core values*. These are guidelines which contribute to creating a good working and learning environment and they clarify what is expected of each individual employee. The ITM School considers active employeeship as the foundation for good work, and acknowledges that the working environment should play a strong role in inspiring and motivating employees. Staff engagement is an active and solid part of a successful organization, and therefore the objective at ITM is to enhance the individual perspective and clarify expectations. The responsibility

⁴ www.di.se/nyheter/svensk-export-slar-rekord-pa-alla-hall/

⁵ thenordicweb.com/stockholm-now-accounts-for-1-in-3-investments-in-the-nordics/

⁶ High-technology employment in the European Union. Goos, Maarten ; Hathaway, I ; Konings, Joep ; Vandeweyer, Marieke KU Leuven VIVES; Leuven (Belgium), VIVES discussion paper 41 VIVES discussion paper 41; 2013; pp. 1 - 59

for maintaining a good working environment and for providing a supportive organizational foundation lies, obviously, with the management. Thus to improve our working environment, ITM will focus on better interplay between good management, active leadership and employee engagement.

Internal communication and learning from each other is important for any organisation, and the process of sharing information and experiences offers opportunities for us to develop both personally and professionally. By such sharing, ITM will strive to become stronger through *communities of practice*. The language policy at KTH emphasizes parallel language competence in Swedish and English for all staff. Language and communication skills are a means to strengthening employeeship, fostering integrated communities of practice, and enriching our international setting. ITM will inspire, support and value parallel language capabilities.

At ITM all employees and students are equal and consequently equally treated. Diversity is a strength which we are continuously learning to utilize to its fullest. Despite this, there is a lack of universal knowledge in several aspects of equality, diversity and equal treatment – for example, what constitutes discrimination or sexual harassment, and how behaviour can be perceived between different employees and students, and also for basic facts e.g. about gender balance in the organization. In addition, strategies and activities for reducing and eventually eliminating discrimination are in general not well understood. However, recent efforts in a few departments and education programmes are showing good results, and there is a common positive attitude to develop actions to secure equal treatment at ITM.

In the near future, education concerning equality, diversity and equal treatment will be given at the ITM school, starting specifically with managers at all levels. ITM will also align with the improvement of KTH recruitment processes that will address equal treatment with proactive measures for increased gender balance. Equality and diversity will become issues for which a dialogue is continuously kept active, in order to improve the academic environment.

3 Research

3.1 Vision for Research

ITM should be a leading research environment in Europe in technology and management, driving towards a sustainable future. Specifically this entails contributing in every way we can towards a fossil free, climate-gas neutral industry and society by 2040, and towards an industry which by 2050 contributes to actually reducing climate gases.

3.2 Introduction

In parallel to the huge sustainability challenges, we are faced with mega-trends such as digitalization, urbanization and demographic changes which in turn pose challenges and opportunities that cannot be addressed by a single individual or organization. Effective collaboration will be the key to success.

The technological shift embodied by digitalization provides unprecedented opportunities for innovation⁷. With this shift we refer to smartness, automation and connectivity, combined with other technological developments and a transition towards a global data and service economy.

Digitalization also poses several new challenges and threats referring to the need for new business models and the unprecedented complexity of future connected smart industrial systems, which have to be engineered to be sufficiently safe, secure, available and cost-efficient. Emerging digital technologies are present in the different fields at ITM. However, specific research into how digitalization transforms business and systems engineering methodologies that provide resilient systems for a circular economy is still in its infancy. The potential of connections between current research areas at ITM creates exciting opportunities to lead development.

ITM will make efforts in establishing research areas within digital transformation and industrial disruption. An initial step is to provide a cross-disciplinary platform where workshops, seminars and other traditional academic activities can fertilize the development.

⁷ Highlighted by terms such as the industrial internet of things, industry 4.0 and cyber-physical systems.

We believe that we are at a turning point, where these advancements need to be put into action in order to counter climate change as well as to address other societal challenges, and drive towards a circular economy. Technical disruption alone will not be enough but must be supported by innovation and entrepreneurship.

The corresponding endeavours require that universities, many of which were set up a hundred years ago or more, scrutinize their roles and organization. Addressing the mentioned challenges will require new cross-discipline/cross-domain approaches that leverage deep disciplinary knowledge to create system level methodologies encompassing the life-cycle (over design and manufacturing), materials, information technology, systems and design thinking, and business models. Competitiveness will require increased agility by universities to act, strategic collaborations, strong regional ecosystems involving education, research and industry, and more of life-long learning.

This situation places the ITM school at KTH in pole position. As stated on page 1, about 10 % of the MSc Engineers graduating annually in Sweden come from ITM, giving us a huge responsibility – and opportunity – to influence the competence and perspective of future engineers, to prepare them to be part of the solution to the world’s challenges. . The ITM School will act by providing new knowledge and competence, driving towards a sustainable future. The corresponding vision, goals and means are formulated to address this.

3.3 Goals and means to reach the vision

The vision will be reached by fulfilling the following goals:

- i. **Create awareness** of climate change and sustainability challenges, and develop the culture of collaboration, innovation and entrepreneurship needed to address the challenges.
- ii. **Attract top talents and qualified staff who are ready to take on the tasks**
- iii. **Contribute to the transformation of industry** in key ITM related fields (such as manufacturing, energy and transportation) by focusing research in the relevant areas, connecting research and education, establishing best practice exchange with and within industry, and by developing new interactive forms for collaboration.
- iv. **Create strategic collaborations and networks** with relevant stakeholders within the ITM research profile while sharing the same vision; engaging regional, national and international organizations, covering relevant eco-systems of stakeholders.
- v. **Create incentives, resources and infrastructure**; exploit synergies and existing resources that support actions driving towards the vision. This includes developing suitable funding strategies and proactive measures for establishing funding.

To reach the stipulated goals, an action plan will be formulated, including establishing (I) **a process for continuously monitoring and communicating KPIs**, performed in collaboration with KTHB; (II) **ITM as a living lab for human compatible digitalization and sustainability solutions** to promote collaboration, demonstrators and open innovation - closely related to the Innovation Arena; (III) **support measures and incentives** to facilitate living-lab initiatives, provide efficient multidisciplinary project management and administration, and proactively drive key research areas; and (IV) **effective communication of what we do**, spreading awareness to external stakeholders.

As mentioned in the introduction, KPIs will be developed to help promote awareness of (and drive towards) the School’s vision, and also clarify what we mean by “leading”. The intention is to go beyond the traditional academic model (with the usual university ranking KPIs such as citations and collaborative authoring), and include KPIs that capture aspects of essential multidisciplinary and industrial collaboration, connections between research and education, and research impact towards sustainability.

4 Education

Approximately a third of the student population at KTH is registered at ITM. The School currently hosts nine degree programmes in engineering (7 MSc and 2 BSc), as well as several one- and two-year master programmes and a technical preparatory year/semester. Our engineering programmes are well recognized, with a quality, nature and content that results in a high employment rate for graduating students. A majority of the programmes involve international cooperation, through network participation, student exchange schemes, shared master programmes, teacher exchange, and MSc and BSc thesis projects performed abroad (for example, as Minor Field Studies). Many of our courses are aligned with the CDIO pedagogy, and we utilize many external partners from society and industry enabling study visits, guest lectures, “real-life” projects in courses and degree projects. In addition, our master programmes have a close connection to research thanks to their location at departments with well-established research.

However, there are also challenges that the School’s educational development will focus on. For instance: How to compensate for the fact that education has a much lower status compared to research, and the fact that the tenure track system does not incentivize educational renewal; How recent developments in data management and storage techniques (such as cloud solutions, big data tools and analytics) should be integrated in the programmes - this could potentially be seen as a critical gap in knowledge for future engineers; How to remain agile enough in our educational efforts to cope with continually evolving technological advances, the combination of technologies, the adoption of newer or non-conventional business models, all of which motivates focusing on Innovation and Entrepreneurship – after all, our students are almost as likely to start new companies, or become consultants in emerging fields, as they are to go into large established engineering corporations.

Changes in industry and society lead to changed needs in education, both in content and in the way we collaborate with other disciplines. One good example is the way that major technological innovations in the last decades have transformed the finance industry. This transformation continues and our education has become, and will continue to be, an important provider of engineers with the required combination of deep knowledge in finance, mathematics and computer science.

All together, these factors strongly motivate educational renewal and continuous strategic educational work with the intention to both overcome the described weaknesses/limitations, including reviews of our program offerings and how undergraduate and graduate programs are connected.

4.1 Vision

ITM’s engineers and STEM⁸ teachers solve both local and global challenges for a sustainable future, and operate effectively in international contexts.

Therefore by the year 2023, we plan to extend our current efforts to:

- i. Provide the best research driven education in a creative, innovative, sustainable learning environment characterized by supreme quality and a distinct identity formed by excellent students, qualified staff and committed faculty.
- ii. Execute teaching characterized by excellent pedagogics and a profound integration of flexible and personalized education, to meet the needs of future generations of students
- iii. Provide a balanced working environment emphasizing gender balance, diversity and equality among both staff and students.
- iv. Educate within the context of national and international challenges, with extensive knowledge focused especially on sustainable engineering

⁸ Science Technology Engineering and Mathematics

4.2 Goals and means to reach the vision

Clear contribution to sustainable engineering

By 2023, ITM will clearly contribute to a more sustainable society, through a variety of life cycle studies and incorporating sustainable engineering influences in every aspect of our programmes, from the beginning and all the way through the education. The main objective is to give the students a holistic view of sustainability from a societal perspective, with the additional aim to strengthen the competitiveness of industry. During their education our students are trained to apply several different sustainability aspects in many different contexts. The focus for our sustainable engineering education is on management, control and technology development of components and products, energy supply, the use of new materials and different manufacturing methods.

Increased knowledge and awareness of gender and equality issues

At the ITM School diversity is considered an asset. Through their education, ITM students will acquire sound knowledge of gender equality (both quantitative and qualitative aspects) and diversity that they then are able to apply in different ways in their future workplaces. By 2023 all ITM teachers will have taken a university education course in diversity and equal treatment. Furthermore, we will undertake special efforts to increase the percentage of female students in our programmes, and address student recruitment from different socio-economical backgrounds.

Good preparations for future global challenges

Internationalization is a natural part of the ITM School's education, thus preparing students for a globalized labour market. By 2023 we will therefore regularly host international exchange possibilities for staff, teachers and researchers to enable increased knowledge transfer regarding global challenges. We will also expand our international partnerships and have a well-integrated internationalization perspective for our students' exchange studies, as well as extensive possibilities for exchange students from other universities to join us. Thus, we will offer a significant amount of relevant English speaking elective courses.

Extensive industry cooperation

By 2023 the strengths of ITM's programmes will be well-known and well communicated, not only at KTH but also in industry and society. Each and every one of the students at the ITM School will also have extensive elements of industrial and societal challenges included in their education. This is achievable since the entire faculty collaborates with potential employers in such a way that our students work with a range of reality-based, interdisciplinary challenges. Therefore, by 2023 all of our students will benefit from our extensive industry collaboration and many of their courses will incorporate study visits, guest lectures, reality-based case assignments, company-initiated project work and graduate assignments anchored in the students' future career role.

Strong enhancement of I&E and student-centred teaching environments

By 2023 we will provide innovative environments, for both teachers and students, aimed to promote, explore and encourage interdisciplinary development. The ITM School will thus have extensive laboratory elements in all of the programmes and offer students extensive open access to experimental, physical and digital learning environments. All students should, during their education, have great opportunities to practice their skills in relevant fields of technology. In the education activities at ITM we will also offer stronger integration of Innovation and Entrepreneurship (I&E) expertise (e.g. from KTH Innovation and Stockholm incubators) and more resources to develop I&E projects beyond immediate coursework (e.g. maker spaces).

Extensive pedagogical development

At ITM, we aim to create an environment that facilitates life-long learning, where faculty development and higher pedagogical competence constitute important aspects in strengthening our academic teaching. Thus by 2023 ITM faculty will have contributed to the development and implementation of a merit structure for recognizing excellence in pedagogy at KTH, developed a process for validating teaching skills and also been actively engaged in SOTL (Scholarship of Teaching and Learning). By 2023 all our teachers will fulfil KTH's demand for qualifications within higher pedagogical competence, and all of our educational managers (program directors, deans of education and study directors) will undergo the higher education courses that are required during their term.

Comprehensive integration of digitalization

By the year 2023 the practice of teaching at the School will be enriched with new technological possibilities due to digital learning platforms that offer a wide variety of functionality. Students with degrees from ITM's programmes will have the necessary digital skills, as defined by OECD⁹. Digitalization has an obvious role in all ITM courses, is a natural part of all programmes and a given point of departure for ITM teachers when courses are to be further developed. The digitalization of our education also enables the students to an increased knowledge on how to use digital tools in their future working life.

Finally, to reach the stipulated goals, yearly action plans will be formulated and communicated, focused on the following areas. (I) **Engineering for sustainability**. Since ITM is part of a leading technical university, it is essential that we educate engineers who consider environment, society and economy simultaneously in the development of products and processes to create a sustainable future. (II) **Changed student population**. The diversity of our students (e.g. geographical origin, ethnicity, academic tradition, gender) should be reflective of society in general. (III) **Comprehensive internationalization**. Internationalization will not be considered a separate issue; rather it will be something that permeates all parts of the School's educational activities. In addition to information, education and training, there should also be more incentives for the faculty at ITM to strengthen their "global skills". (IV) **Innovation, entrepreneurship and digitalization**. ITM intends to take a leading role in the area of Innovation & Entrepreneurship, and also execute an international outlook and "reality check" with partner universities and other leading players regarding best-practice for educational efforts for digitalization, within industrial engineering and management, mechanical and materials engineering.

5 Research education

The quality and success of postgraduate research education is highly dependent on the quality and success of the research environment in which it is conducted. The annual survey to all our PhD students confirms that there is an overall level of satisfaction with the research environment offered at ITM. However, at present, the level of interaction with industry varies within the School and needs to be increased in some departments. The lack of timely course provision is a challenge for many PhD students and requires remedial action within the School to ensure our doctoral candidates can graduate on time. At present the administration of research studies is too focused on process compliance and reporting, with limited direct impact focused on the aspects of research quality and learning outcomes that should be concomitant with quality research education.

5.1 Vision

ITM will focus on a programme of innovation aimed at enhancing the creative, active, equal and inclusive research environments within the School. This is combined with a high level of industrial collaboration, societal cooperation and international interaction through research networks, graduate student exchange programmes and an emphasis on staff mobility. Our doctoral courses will maintain a high quality and emphasise our strengths but we will also build on cooperation with other universities to broaden the supply of relevant courses. ITM will also invite students from other universities to take courses at KTH thereby increasing the availability of suitable courses. PhD studies at ITM should be characterized by flexible processes emphasising the development of high levels of creativity and individual specialisation, overseen by effective quality assurance routines to ensure accountability for educational excellence. All senior faculty members, including adjunct professors, give PhD courses at least bi-annually. The doctoral education process at ITM should be transparent and harmonized, for instance with mid-term seminars and peer-review evaluations to provide a standard model for the conduct and quality assurance of graduate education across all departments.

5.2 Goals and means to reach the vision

To enhance the quality of our programmes, we embrace the following principles for the period 2018 to 2023.

⁹ OECD Digital Economy Outlook 2017

Internationalization and industrial cooperation

All PhD students in the ITM School will participate in international conferences (at least bi-annually), spend at least a few months in another research group, preferably in another country (these visits may be financed through the basic research national funding block if other means are lacking), interact with industry e.g. through industrial students and/or industrial project partners.

Gender mainstreaming

The ITM School will constantly work with gender mainstreaming in the PhD process, e.g. making sure that both male and female PhD students are encouraged and financed to spend time in other research groups and that both female and male students are encouraged for a future career in research.

Courses

As a driving force to give courses in a frequent and timely manner, the development and delivery of PhD courses will be funded and an allocation model will be developed that takes into account the fact that graduate level courses are a mandatory part of the education. The course funding budget should be managed by the persons responsible for the doctoral programmes (DA) in order for them to guarantee a suitable overall offering of courses. This process needs to be transparent and fair, and PhD courses should also be evaluated regularly through course surveys and other evaluations, as stated in existing guidelines for PhD education at KTH.

Administrative systems

The doctoral education is allowed to be flexible and tailored to the needs of the individual student and supervisor, and can rely on the professional skills and knowledge of supervisors. The administrative systems should be developed in close collaboration with the faculty.