Documentation and visibility of innovation at NTNU

Focus on societal impact and collaboration with working life

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NTNU

REPORT FROM THE WORKING GROUP FOR DOCUMENTATION AND
VISIBILITY OF INNOVATION AT NTNU; FOCUS ON SOCIETAL EFFECT
AND COOPERATION WITH WORKING LIFE

NTNU, NOVEMBER 2020

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PREFACE

A high degree of innovation activity is one of NTNUs unique features. NTNU has contributed to the construction and development of the Norwegian industry and business for over 100 years and has ambitions to continue contributing to increased restructuring and innovation in the private and public sector. However, it was first in NTNUs strategy for the period 2018-2025, "Knowledge for a better world", that innovation was clearly defined as one of the core tasks at NTNU, including clear development goals for innovation.

The expectations of the higher education sector to contribute to increased innovation, competence development, and restructuring of Norwegian working life is increasing, expressed both from the Government, via the Ministry of Education and Research (MER) allocation letters, in various governmental reports and notes. Innovation is anchored in NTNUs development agreement with the Ministry of Education and Research for 2021-22, specifically in Objective 4, which states that "NTNU shall make visible and increase the innovation activity and contribute to sustainable innovation from clusters and centres".

NTNU will increase their innovation activity by further developing internal support functions and incentives in order to support NTNUs academic environments, scientific staff, and students to restructure the Norwegian working life. How innovation activity in collaboration with the working life can be documented and visible is highly relevant in this context. There are established routines for documentation of activities in education and research, but routines for reporting the impact of innovation and collaboration with working life are fragmented and partly lacking.

As part of the development agreement with MER, NTNU has already submitted the reports "Towards a broader measurement system for the higher education sector's contribution to innovation" and "How universities contribute to innovation". NTNU delivers a third report; "Documentation and visibility of innovation at NTNU - Focus on societal impact and cooperation with working life". This report provides a good starting point to highlight and clarify innovation activity from academia in collaboration with working life. With an increased focus on interaction between the public/private sector and academia, there is a need for a more explicit incentive system for innovation and working-life cooperation in the higher education sector.

Trondheim, November 2020.

Toril N. Hernes
Pro-Rector for Innovation, NTNU

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Introduction

The work with this report is anchored in NTNUs "Development plan 2019-2021 Increased interaction, innovation and societal effect". The report has been prepared by a working group appointed by Pro-Rector for Innovation, Toril Hernes. The group has consisted of the vice deans Karoline Daugstad, Faculty of Social and Educational Sciences, Brita Pukstad, Faculty of Medicine and Health Sciences, Eva Falch, Faculty of Natural Sciences, innovation leader Anne Nuijten, Faculty of Architecture and Design (until July 2020), Vice Dean Casper Boks, Faculty of Architecture and Design (from August 2020), and senior adviser Ragnhild Nisja from the Pro-Rector's innovation staff. Daugstad has led the group. The Working group has had ten meetings. Everyone in the group has contributed with text in the report. The working group leader has undertaken the final editing. The work has been presented for the Innovation Committee and presented in meetings with the Pro-Rector for Innovation.

Innovation was first included in NTNUs strategy for the period 2018-2025 "Knowledge for a better world" and defined as one of five core tasks at NTNU. A high degree of innovation activity is one of NTNUs unique features and NTNU has ambitions to contribute to increased restructuring and innovation. Innovation is anchored in the development agreement with the Ministry of Education and Research (MER) for 2021-22, specifically in Objective 4, which states that "NTNU shall make visible and increase the innovation activity and contribute to sustainable innovation from clusters and centres".

There are established routines for documentation of activities in education and research, but clear routines for reporting the university's innovation work and collaboration with working life is lacking. If we look at NTNUs strategy and the development agreement with MER, as mentioned above, it highlights the importance of developing these routines. NTNUs "Development plan 2019-2021, increased interaction, innovation and societal effect" states that NTNU will focus on documenting the innovation and collaboration with working life. This work is essential in connection with the DORA Declaration (San Francisco Declaration on Research Assessment). Innovation is a crucial element when applying for research funds, therefore NTNU need to develop and have routines for documenting and visualizing innovation. The development plan says further that innovation is necessary for career development.

With this introduction, Pro-Rector for Innovation designed the following mandate for the work:

The main goal of the work is to contribute to documentation and visibility of innovation activity, and especially activity in collaborations with working life. This will be done by looking at selected cases and examples from NTNU. The examples will reveal both challenges and opportunities. The work with case and examples aim to capture all corners of the organisation.

▌ We want to specify here how we have worked:

First, our focus has been on how innovation activity in cooperation with working life can be documented and made visible. Our aim is not to show which innovation activities occur at NTNU, but to highlight how these activities are communicated and documented. Secondly, the working group has not conducted systematic innovation mapping of what is going on at NTNU. Instead, we have chosen to discuss examples from NTNUs activities that we believe are suitable to illustrate both opportunities and challenges related to documenting and making innovation activities and cooperation with working life visible.

We have not given the term innovation a specific definition. We utilise the term as it comes to expression in the report from the first phase of NTNUs work with an indicator set for innovation (NTNU, 2019): Innovation as an indirect contribution in the form of innovation competence and innovation culture, innovation as interaction, and innovation as a direct contribution through commercialisation and business development or innovations in the public sector and society.

What do we want with the report? The report does not intend to present ready-made solutions. This is not our mandate, or possible to undertake within the time frame and competence of the working group. However, the report is a prelude to further work by giving ideas or encourage further thinking through challenging and inspiring. The target group for the report are faculty or department leaders as well as leaders of various scientific units, centres or projects. These are also leaders who must consider how to bring our proposals forward. Further, we hope that the report can be interesting for scientific employees involved in research, teaching, and innovation. We envision that the report may also be of interest to various working life forums or bodies affiliated with NTNU, for example, the various Councils for Cooperation with Working life.

The report is structured as follows: In chapter 2, we first give an outline of what we have called "Backdrop internationally, nationally, and locally at NTNU". This leads to what we call the "Envisioned challenges" at the end of the chapter. Then follows chapter 3, which we have called "Insight", where we shed light on the envisioned challenges and include examples of how innovation in collaboration with working life works at NTNU. Finally follows chapter 4, where we share advice and recommendations for further work with visibility and documentation of innovation in collaboration with working life at NTNU.

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Backdrop internationally,
nationally, and locally at NTNU

2.1 Innovation in the context of international ranking

University rankings have received increased attention in recent years. Rankings can have different focus, and there are general rankings as well as rankings that focus specifically on innovation. Appendix I shows how universities are ranked on "The Reuters Top 100 Word's Most Innovative Universities"[1]. Here we see that KU Leuven, Belgium, in 2019 is No. 1 on the list of the most innovative universities in Europe. Success criteria for the list are the number of patents, success rate and commercial impact. NTNU is no. 56 on Reuters' top 100 list. If we look at the distribution between countries, German universities are most represented in the top 100 with 23 institutions, followed by the United Kingdom with 21 universities, France with 18, The Netherlands with 9,

Belgium with 7, Spain and Switzerland with 5, Italy with 4, Denmark with 3, Norway with 2 and Austria and Ireland with 1.

International rankings are not a goal in itself, as the choice of indicators is decisive for which universities top the lists. However, indicators can be a tool, among several, to target efforts to contribute to solving the significant societal challenges we face. National authorities and the national and international society have growing expectations that universities must contribute to the green shift and development of sustainable solutions. International rankings are one of several inputs in developing an indicator set for innovation, which is described in 2.6.2.

2.2 National processes related to academic merit and innovation competence

In recent years, several processes at the national level have focused on employment structures, career paths, and competence in the higher education sector. "Underdalsutvalget"[2] delivered in May 2018 a report to the government with proposals to change the employment structure for academic positions at universities (Stillingsstruktur ved universiteter og høyskoler, 2018). In the report, the committee states that the position structure shall cover the sector's core tasks and the additional functions required to carry out the broad societal mission: Core tasks are education and research and contributing to social, cultural and economic development in society. From an institutional point of view, it is also essential that a new employment structure is robust, however at the same time flexible enough to handle external and internal

influences - be it political guidelines that change or adjust the societal mission, new mergers in the sector, or a change in future funding pattern. Innovation competence is not mentioned as a core task in the employment structure in the report from "Underdalsutvalget". Still, it is pointed out that the sector's contribution to value creation and innovation in business and the public sector is a central part of the societal mission. The "Underdalsutvalget" proposal has received both support and been challenged but has not yet been implemented (per October 2020).

The Ministry of Education and Research approved, on September 12, 2018, amendments to "Regulations on employment and promotion in teaching and research positions" (Forskrift om ansettelse og opprykk i undervisnings- og forskerstillinger, 2018).

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1 https://graphics.reuters.com/EUROPE-UNIVERSITY-INNOVATION/010091N02HR/index.html
2 Underdalsutvalget, a national committee led by professor Arild Underdal, University of Oslo.

Paragraph 1.1 states the following: "The regulations establish the general criteria for employment in teaching and research positions at institutions as stated by the University and university college act. ...All educational institutions shall develop more detailed criteria for employees' educational competence and how this is documented".

Furthermore, the regulation states that in addition to the required basic competence in teaching and supervision at the university and university college level, associate professors must document the following when applying for promotion to professor:

• Development of teaching and supervision over time
• Extensive experience with supervision, preferably at master's / PhD level
• Participation in the development of educational quality together with peers.

Innovation is not explicitly mentioned in this regulation.

Looking outside Norway, there is guidance for research evaluation through the international DORA Declaration, or "San Francisco Declaration on Research Assessment". This declaration includes a set of recommendations prepared by a group of editors and publishers. The recommendations highlight the importance of giving different outputs from research recognition at research institutions, research funding bodies, and from actors who publish research. The broad understanding of output includes research articles, data, software, IP, and educating researchers. The DORA Declaration states that when evaluating impact from research, all types of outputs should be considered, in addition to, of course, research publications. Thinking broadly about impact includes qualitative indicators such as the influence of research on policy and practice. NTNU is affiliated with the declaration, and all new academic job announcements include the DORA Declaration's principles.

Summary

This section pointed out that the DORA declaration takes a broad view on output from research. National guidelines concerning employment structure and merit do not explicitly focus on innovation as a recognised competence.

2.3 Relevance of innovation in research assessments

Output from research varies according to purpose, context and circumstances. Let us look at how research is evaluated when it comes to research applications. It is interesting to look at how the EU system and the Norwegian Research Council operates. The overall criteria for evaluating applications in Horizon 2020 are "excellence'", "impact", and "quality and efficiency of the implementation". All types of projects define impact in relation to the goals of the individual calls; "The extent to which the project's outputs would contribute to each of the expected impacts mentioned in the work program under the relevant topic". For research and innovation projects, this is said to impact: "Extent that the proposed work is beyond state of the art, and demonstrates innovation potential (e.g. ground-breaking objectives, novel concepts and approaches, new products, services or business and organizational models). Appropriate consideration of interdisciplinary approaches, and, where relevant, uses stakeholder knowledge and gender dimension in research and innovation content" (Horizon 2020 - Work program 2018-2020, General Annexes). We see that innovation is linked to impact. It is reasonable to assume that this view on impact is also continued in the forthcoming program, Horizon Europe.

A specific point of interest concerning innovation in Horizon Europe is the new three pillars framework:

Excellent science, where a focus on radical, curiosity-driven research under the European Research Council (ERC), mobility instruments under Marie Skłodowska-Curie Actions and research infrastructure will be continued.

Global challenges and competitive business, where six broad clusters are established, continue focusing on societal challenges and industrial leadership (enabling technologies) in Horizon 2020. Under pillar two, collaborative thematic research and innovation projects will be financed. Multidisciplinary collaboration is prioritised.

Open innovation, here the most important new initiative is the establishment of the European Innovation Council (EIC - European Innovation Council) with two main instruments: Pathfinder and Accelerator. Under pillar three, an initiative is also established to build better ecosystems for innovation, and funds are set aside to continue the European Institute of Innovation and Technology (EIT).

Looking at the Norwegian Research Council's (NRC) framework for evaluating research applications, they use the same main criteria as the EU system[3]. From 2019, NRC introduced new assessment criteria for all applications: Research-quality/research and innovation (excellence), effects (impact), and implementation. The content of the three criteria is adapted to the individual application types but has a similar structure. Effects/impact is narrowed down to potential effects/impact of the proposed research and innovation and plan for communication and utilisation of results.

Summary

As a summary of this section, we can say that there is a clear focus on impact, innovation and societal benefit in systems that fund research both within EU and nationally, but there is lacking clarity how this should be described and argued for in research applications. We have reason to believe that this is described in different ways in different academic environments at NTNU and that this can be perceived as demanding. The working group aim to focus on ways to document innovation that can make it easier to communicate impact in research applications.

2.4 Innovation through collaboration between working life and education programs

It is today's students who must solve tomorrow's challenges and create tomorrow's jobs. What actions education leaders and educators take with the education programs is therefore of great importance for societal impact and the ability to innovate.

Collaboration between the students' future working life and the education programs can have many different forms and affect innovation and societal effects in general. The term working life relevance is often used for what one wants to achieve through collaboration. The government report "Culture for quality in higher education" (Meld. St. 16 (2016-2017) shows many different examples of cooperation between different university campuses and working life; collaboration on curricula, educational goals, product development, common entrepreneurship activities, innovation and entrepreneurship training, guest lectures for career days, company visits and company presentations. These forms of collaboration can have a different impact on students' ability to innovate: From students training in the professions they are heading into, preparing students for the transition to working life, as a motivation factor for students to complete their studies, to the more strategic development-oriented forms of collaboration where students meet working life relevant challenges that can contribute to their fulfilment of society's competence gap, increases creativity and innovation potential. The need for working life relevance is emphasized in the report "Higher education in Norway - labour market relevance and outcomes (OECD, 2018). It concludes that "Norway's higher education system needs to be more engaged in practices that will enhance its labour market relevance and outcomes".

National Qualifications Framework:
Skills within general competence:

- at bachelor level: The candidate knows innovation processes
- at master's level: The candidate can contribute to innovation processes
- at the PhD level: The candidate can assess the need for, take the initiative and drive Innovation

The national qualifications framework for higher education states that innovation should be included in all Norwegian study programs (Nasjonalt kvalifikasjonsrammeverk for livslang læring 2014, see text box above). However, it seems that this requirement is not fulfilled for all study programs as of today. Implementation of innovation as a learning outcome in the different study programs will be necessary for the future. Within health and social science education courses, innovation as competence is specified through learning outcome descriptions in the new RETHOS guidelines (National Guidelines for Health and social sciences education[4]), as described in chapter 3.3.3.

The government has announced that a separate report on working life relevance in higher education will be published in spring 2021[5]. The overall ambition of the report is to strengthen the quality and work relevance in higher education. The increased focus on work relevance in higher education can be linked to the concept "Employability". This can be defined as a set of achievements - skills, understanding and personal attributes - that makes individuals more employable and successful in their chosen occupations, which in turn benefits themselves, the workforce, community and economy' (Bui et al., 2019). The new governmental report emphasises that students need to be better prepared for working life. Working life should have access to relevant expertise that can contribute to development and restructuring. The ambitions are to be reached through:

- Better and more cooperation between universities and university colleges and working life about society's knowledge needs, development of higher education and students' learning,
- to strengthen the quality of working life practice in educations with a high amount of compulsory practical training,
- to strengthen the working life connection to educations that have a weak connection today,
- to strengthen innovation and entrepreneurship in higher education.

Summary

In summary, we see that innovation and relevance to working life are emphasised strongly in leading documents and reports for higher education. NTNU must document that we educate students who are working life relevant, contribute to necessary development and restructuring, and make such competence visible to future employers.

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4 https://lovdata.no/dokument/SF/forskrift/2017-09-06-1353?q=helse-%20og%20sosialfag%20l%C3%A6ringsutbytte
5 https://www.regjeringen.no/no/aktuelt/om-arbeidsrelevansmeldingen/id2638895/

2.5 NTNUs Council for Cooperation with Working Life - NTNU RSA

As shown above, emphasis on cooperation with working life, in guidelines from authorities and national bodies, is already institutionalised at NTNU through three thematic Councils for Collaboration with Working life - RSA (in Norwegian). Background for the establishment of the Council for Cooperation with Working life is given in St. meld. No. 44 (2008-2009) "Education strategy". Cooperation between education and working life should ensure that the educational offerings meet the skills needed in the working life and stimulate more innovation. The establishment of RSA will ensure that the cooperation between the individual institution and working life is better structured and anchored in the institution's plans and strategies.

NTNU has RSAs in three academic fields: "NTNU RSA Health and health-related technologies", "RSA Technology and Business", and "NTNU RSA School, culture and welfare". The RSAs are organizationally placed on a level below the top management level. NTNU RSA has a separate mandate from NTNUs board in August 2016. RSA has another function than the NTNUs board, faculty board and study program council and constitutes a professional meeting place for interdisciplinary dialogue with working life. RSA facilitates new collaborative relationships across organisational and geographical boundaries. At the start of the work with NTNUs three thematic RSAs, two central issues emerged: Work relevance in the educational process and how to improve working life representatives' possibilities to get in touch with relevant academic environments at NTNU. Based on input and discussions in NTNU RSA Technology and business, a separate project was started. This project aimed to map non-compulsory practical training activities in different study programs. Professor Helen Jøsok Gansmo is the project manager. The mapping project was initiated in winter 2019. Findings from this work are presented in part 3.3.4.

In the autumn of 2020, NTNU is in the process of evaluating various models for continuing NTNUs RSA.

2.6 NTNUs support system for innovation

NTNU currently has a comprehensive and multifaceted support system for innovation and innovation, and we will in this section present it.

2.6.1 The development agreement with the Ministry of Education and Research, and NTNUs support system for Innovation

As mentioned in the introduction, NTNU, through its development agreement 2021-2022 with the Ministry of Education and Research clarified their ambitions: A high degree of innovation activity is one of NTNUs unique features. NTNU has the aspiration to contribute to the green shift by utilising more of the knowledge and results from NTNUs broad research activity to form new innovative and sustainable solutions that benefit society and working life.

NTNU will increase innovation activity by further developing internal support functions and incentives so NTNUs academic environments can utilise national instruments and participate in EU innovation-oriented programs. In addition,

innovation will be more clearly anchored at all management levels, a new IPR policy will be implemented, and instruments to increase the pace and innovation in the professional environments will be further developed. NTNU will increase student innovation by establishing an own student hub and piloting how innovation and entrepreneurship competence can be integrated into education, including the PhD programs.

NTNU will facilitate increased innovation from clusters and centres. With experiences from the university municipality collaboration, NTNU will concretise a model for how universities and municipalities can contribute to increased innovation in the public sector. NTNUs ambition is to take an active, nationally leading role in Norway's participation in the Digital Europe Program.

NTNU has developed an indicator set structure for the innovation contribution from the higher education sector. NTNU will carry out pilots for testing the indicator set and make visible and convey innovation contributions from the sector through this.

The support system at NTNU can be categorised into three main groupings:

– Nationally agreed on framework conditions (the Ministry of Education and Research, the Norwegian Research Council etc.)
– Strategies and policies adopted by NTNU

– Own instruments at NTNU; personal resources (for example, the rector's staff, Innovation leaders, EU advisers) and economic instruments (for example, NTNU Discovery, Innovation Scholarship, and various measures aimed at student innovation).

2.6.2 The indicator project

In 2018/2019, NTNU initiated an indicator project intending to prepare a comprehensive set of indicators that can measure the education sector's contribution to innovation, this regarding the Development Agreement with KD 2017-2019. The mission was to understand innovation in a broad sense, not just patents, commercialisation and start-ups, but also other innovative contributions to society. The pilot project was carried out by a working group consisting of NIFU-experts and NTNU employees. The first phase is now completed and summarised in the report "Towards a broader measurement system for the higher education sector's contribution to INNOVATION – proposal for measuring system structure based on experiences from NTNU" (NTNU, 2019), from now on referred to as the Indicator Report. The next phase in developing a comprehensive indicator set is to select some indicators and test, in pilot projects, how these can be implemented. The indicator report suggests a broad introduction to the concept of innovation, as shown in table 1.

Table 1: The main structure for an indicator set with dimensions that illustrate the concept of innovation (taken from NTNU 2019).

Main categories	Dimensions and sub-dimensions
A. Indirect contributions (activities and processes)	**1. Innovation competence and innovation culture** • Integration of innovation in education, research training, etc. • Generation of new ideas, from students and staff • The institution's facilitation of innovation by organisational measures (such as own positions, TTO, incubators, various incentives to promote innovation, etc.) **2. Interaction** • Cooperation in general (including mobility) • Business cooperation in particular (including mobility) • Public sector cooperation (including mobility)
B. Direct contributions (changes and results)	**3. Commercialization and business development** **4. Innovations in the public sector and general society**

In the Indicator report, various use cases are outlined for which an indicator set can be used:

1. Measurement and visibility of the innovation activity and analyses of innovation activity over time.
2. National comparisons of contributions to innovation
3. Basis for policy formulation, corporate governance, incentives and priorities (institutionally and possibly nationally). Indicators are important figures that help us map the change we implement to realise our strategies and assignments.
4. International comparisons for universities' contribution to innovation.

The indicator report discusses the challenges of arriving at specific, measurable indicators that can be registered into an indicator set. The working group noted a need for an indicator set that is pragmatic, possible to use, and includes a broad understanding of the term innovation (from patents, commercialisation and start-ups, innovations in the public sector and innovative forms of artistic development work). This work is essential when trying to document and make innovation visible. In addition, being able to communicate innovations both internally and externally in a qualitative way can and must be used; Storytelling and dissemination of best practice can be considered valuable when expressing the scope of the educational sector's contribution to innovation. This is currently not used much at NTNU. Developing a system to highlight innovation through communicating impact cases will be included when creating the pilot for an indicator set. NTNU's push towards a support system for innovation is done parallel with international work on the topic. The European University Association (EUA) is developing the future model for support systems for innovation and collaboration

with working life, both private and public sector. Pro-Rector Toril Hernes participates in an expert group in the EUA to develop the future "Innovation Ecosystems".

2.6.3 Strategic program for knowledge-based innovation - The SKI program

In January 2018, the "Strategic program for knowledge-based innovation at NTNU" (SKI program) was initiated. The SKI program aims to increase the usage of knowledge, technology, methods, results and ideas from research at NTNU to concrete innovations. The program intends to make knowledge and results from NTNU research more easily accessible for society. The SKI program has two key instruments: Innovation leaders in the academic environments (centres, departments or faculties - most were employed on the 1st of November 2018) and competence meetups. Phase I of the program period is 2018-2021.

The program has been evaluated midway through the period (Bye et al., 2020). The evaluation report highlights several important factors for the visibility and documentation of innovation at NTNU as an organisation concerning cooperation with working life. An overall finding is that the innovation activity in the SKI program is diverse and that work with innovation includes all aspects of the term. Another general finding is that there is a focus on building innovation culture in many academic environments - perhaps most in environments where innovation has not been immediately thought of in the past.

The evaluation points out that one is missing formalised support to assist in the knowledge transfer of innovation that is not directly commercialised. Therefore, it is necessary to develop and establish indicators that also highlight innovations that are not commercialised. It is also pointed out that the SKI program as a shared network and learning arena across units and scientific environments is essential.

The evaluation of the SKI program points out that there are no main incentives for innovation-related work. This applies to both incentives towards academic environments and individual researchers. The incentives that exist are primarily related to student degrees and study credits, and publication in scientific journals. Evaluator thinks it is reasonable to assume that this is significant for some researchers' prioritisation of aligning their work effort.

In the autumn of 2020, the work for better inclusion of service innovation in the innovation work at NTNU started. It is considered whether innovation leaders should have service innovation as their primary focus. This may contribute to the work towards expanding the understanding of the term innovation at NTNU. Since service innovation often occurs outside of the business world where commercialisation, start-ups and patents are often used as a benchmark. Service innovation may be especially relevant in public (and not least health) sector.

2.7 The total picture of challenges

Based on the "backdrop" presented in this chapter, we summarise the following challenges related to documentation and visibility of innovation at NTNU:

General challenges: There is a broad focus on deliverables and output from research and innovation activities. In many ways this challenges the classical role of universities. NTNUs mission, and how this is achieved, impact the income basis (transfer from KD). Visibility of our contribution is required both in quantitative and qualitative ways to develop ourselves in this context.

Challenges in the context of research: A consequence of the challenging role of knowledge institutions is that external funding sources require documentation of innovation ability, impact, and concrete contributions to society. Research results must be made visible and relevant to the business and public sector, which some university staff have limited experience doing.

Challenges in the context of education: Within education and the universities study portfolio, there is increased pressure on work-life relevance, "employability", innovation, and competence in handling change and restructuring. NTNU needs to make students' knowledge and competence in innovation more apparent and in addition make educators' work towards strengthening working life relevance more visible.

Challenges in the context of merit: The challenges within research, innovation and education, influence the scientific employees' role at NTNU and what is significant for a career path. Currently, no systems or routines address the significance of innovation in a career path at NTNU.

The challenges above are primarily related to external expectations from the government and ministries that follow annual allocation letters from the Ministry of Education and Research.

In an overall context, we can declare that society increasingly demands that universities showcase their knowledge production. In addition, universities should highlight the importance of educating 'change agents' equipped to take charge of significant societal challenges.

03

What gives us insight?

What gives us insight into the challenges outlined above? In this chapter, we will share our insights through the work in the group. We highlight a selection of examples from different parts of NTNU. These examples clarify the challenges and show how the academic environment at NTNU can meet the challenges.

3.1   Deep dive: How does NTNU work with innovation, seen from a leadership perspective

We wanted insight into how leaders at NTNU think about innovation and collaboration with working life in their unit. We wanted to understand how they facilitate this and how they perceive their role in promoting innovation within their unit and their academic staff. To acquire this insight, we have interviewed leaders at the department and faculty level. We have not focused on centre managers or project managers. We have chosen leaders for units with significant innovation activities and collaboration with working life, and leaders where innovation and external collaboration is a less prominent activity. Further, the interviews include leaders from units merged with NTNU in 2017 (units from previous university colleges) and leaders of units that has not directly been affected by the merge. The interviews include leaders from all campus cities. We want to emphasise that there are too few interviews to generalise our findings to represent NTNU as a whole. Still, the interviews have, first and foremost, given us insight into some of the challenges we have chosen to focus on (cf. section 2.7).

3.1.1   Innovation in the organisation

The units with long experience with innovation and cooperation with working life describe these as focus areas for the management as well as for the employees. Leaders with a background from the merged units say that close collaboration with working life (industry or public sector) was central before and now - but a lot has changed by becoming part of NTNU. Expectations towards bringing in external

research projects were there before but have been intensified. Expectations related to scientific publishing has increased. There is some concern that relationships with working life can be weakened because employees do not find time to meet all expectations and priorities. Although leaders emphasise the importance of working life contact to improve study programs, the teaching load is perceived as demanding. It is emphasised that students must become change agents.

Some believe that innovation is a result of interdisciplinarity. NTNUs academic width has an excellent potential for increased interdisciplinarity. Utilising this innovation potential is one of the principal tasks for all NTNUs leaders. Leaders should have a broad overview and strengthen the interdisciplinarity that is required to drive innovation. This can be challenging, because interdisciplinarity implies that one has to invite other environments into collaborative projects. This can be at the expense of short-term financial interests. It is said that: "a leader must stand steady to dare to focus on interdisciplinary collaboration".

There are some concerns related to employees' health due to the high expectations. At the same time, it is communicated that new research projects and scientific publications are necessary. All of this is perceived as very demanding to fulfil. Some leaders raise the issue of generations and age, indicating that the employees that are recruited now must be active researchers with high publication rates. Applicants who lack this will not proceed in

a hiring process. Those close to retirement age came to the organisation when the research pressure was lower, and it is perceived as demanding to readjust.

The most forward-thinking 'innovation promoters' among those interviewed believe that leaders should expect more from their academic staff. Clear expectations for innovation are essential to succeed with innovation. Visibility comes from requesting updates on innovation activity at various meetings, including dialogue meetings and management meetings. This can create a positive and supportive narrative connected to innovation. Talking about the importance of innovation will drive the organisation in such a direction.

One of the interviewed leaders believes that deans and department heads must not wait until 'the management level above' tells them what to do. They should instead find ways to work with innovation that are relevant to the organisation they lead.

3.1.2 Innovation occurs in relationships and interaction

Innovation happens in relationships between people, and innovation grows over time. Innovation requires meeting places where contact between NTNU employees and companies or industry leaders can develop. In many cases, this will facilitate increased trust and build long-term connections. As one interviewee noted: "There is no point having something in a drawer and bring it out and then it becomes innovation of it."

The same focus on relationships is essential for students at all levels. It is especially important concerning students writing master's theses in contact with a company or organisation. Interest in master's projects with innovation potential varies, of course, from student to student and from supervisor to supervisor.

The working life perspective in the studies implies that it is essential to have teachers who have working life knowledge, preferably through their own work experience. "It is not applauded to hire someone without a PhD degree, but it is essential for our study programs". This statement says something about the expected research career path, but it also highlights the necessity of other skills than PhD from a study programs perspective.

3.1.3 The merit perspective

Having annual individual meetings with employees where career discussions are included are important to the interviewed leaders. The professor career path is the most common, but some leaders propose that there should also be development opportunities outside this path.

There are different views regarding the possibilities for merits and the promotion processes to a full professor for those who work with innovation. One leader says that innovation is mentioned in the current assessment guide for promotion. The leader goes on to highlight that it is not clear how innovation is to be documented. In a promotion application, you can document research through publications, the success rate on research applications, or the number of projects you lead. This is not as intuitive when it comes to innovation. Innovation is therefore often listed under 'other professional contributions' or similar in a promotion application. A few can list patents or business start-ups, but this will be more exceptional. Other innovation activities are demanding to visualise and document. Other leaders mention the promotion requirements for professors as strict; for example, they should have led major international projects and a high amount of teaching to succeed with the promotion application. Innovation activity does not necessarily have a clear stand in the process. Several leaders say that for innovation to be better integrated into the promotion processes, this must be

addressed nationally and not something the academic environment or NTNU alone can solve. Several say that supervising PhD students is an essential element in a promotion application, but this requirement becomes challenging to meet when PhD students are lacking. For some academic environments, only few PhD scholarships are available through NTNUs strategic funds, and if there are to be more, they must come from external funds.

Some leaders underline that they have the possibility to 'steer' employees' time used on various tasks and through this facilitate individual competence development. Our impression from all the interviews is that this adaptability is used with caution. If professors have major academic leadership tasks, they get less teaching, but this applies to a few. Some units also have scientific staff who teaches more than others, but the examples are few.

When it comes to the employees' hours spent on innovation projects or collaborative projects with working life, none of those we have talked to has a systematic approach to this. Some say that if an academic employee, for example, wants to hospice in a business for a period of time, the person can get a reduced teaching load. However, if this were something many employees wanted, we had to develop a system, and the employee had to make a clear plan. This can be something similar to a research sabbatical.

Some say that they have regular meetings with the staff that thematises innovation. Others say that if any employees succeed in starting a business or getting a patent on a product, this is celebrated, but this rarely happens. One of the interviewees

talks about one local incentive scheme where 50,000 NOK are provided to the academic environment that delivers an idea to TTO (NTNU Technology Transfer Office). This enables management to express that innovation is essential - something that hopefully contributes to cultural change. At the same time are such schemes probably difficult to introduce everywhere due to different economic situations and various focus among units. It is also important to realise that positive storytelling around innovation can be an essential measure throughout the organisation but should probably not happen the same way everywhere; different academic communities will need other ways to see that innovation work also applies to them.

Some of NTNUs departments are interdisciplinarity where innovation is integrated into much of the activity, both in research and teaching. Why this integration is present in only some departments is unclear. One possible answer might be that qualitative storytelling about interdisciplinarity and societal benefit and an inviting culture towards partners contribute to making innovation visible - perhaps to a greater extent than pure quantitative methods. This is relevant when looking at the term innovation broadly, which is prominent in the public sector where the benefit to society can be obvious even if it is difficult to quantify. This conclusion has already been proposed in the report from the indicator project (NTNU 2019).

3.2 The Project Innovation Climate

The Faculty of Natural Sciences has completed the project "Innovation Climate". A design-driven innovation process was conducted to systematically promote innovation activity at the faculty. The design-driven approach with the user in focus provides an essential insight of value when solving challenges. This type of process was for example previously utilised to point out activities for student recruitment at NTNU (Falch, 2015). Project "Innovation Climate" has used the 4 phases of identification, insight, idea and implementation as working principles. The identification phase has received the most focus to ensure that one has a well-informed starting point before starting the systematic insight job. The pro dean for innovation led the project, and the project participants were mainly the faculty's innovation forum which consists of representatives from each department, including the innovation leaders.

Numbers from project innovation climate

> 50 interviews/report reviews
↓
> 280 traces (quotes/facts)
↓
14 areas of opportunity
↓
> 120 ideas
↓

More than 50 interviews or report reviews were conducted in the "Innovation Climate" project. This resulted in over 120 ideas with a plan to implement the top 10. During the insight phase, employees at all departments, managers, employees at other faculties, partners, entrepreneurs, TTO, pro-rector and more were interviewed. The results reveal that scientific employees at the faculty call for the following: Recognition and visibility of innovation work; Merits; Support functions; Room to manoeuvre and flexibility; Tools etc. The insight work also reveals a desire from employees to contribute more towards significant societal challenges, sustainability, and multidisciplinary collaboration.

The 14 areas of opportunity that was of particular importance when promoting innovation at the faculty are shown in table 2. Three of the 14 opportunity areas highlight the need for increased focus on the users associated with conducted research and education. Insights from the interviews show that several areas of opportunity are not restricted to the Faculty of Natural Sciences but is equally relevant to other parts of NTNU.

The project group have learned a lot from performing a design-driven process. From better understanding of how to balance the role as creative vs critical/analytical, how to think outside the set expert role, and how to embrace a more user-focused function. These skills could contribute to a better innovation climate.

Table 2. Results from the project "Innovation climate" at the Faculty of Natural Sciences (NV): The 14 opportunity areas that the insight work pointed out as areas of particular importance for achieving the goals of promoting innovation at the faculty. Status/priority shows which areas of opportunity where ideas have been developed, which are not prioritised, and which are recommended that NTNU continues for all faculties.

Opportunity area	Status/priority
From calling...to merit • How can NV stimulate innovation work by giving acknowledgement to employees?	Ideas for piloting NTNU
Set the innovators free • How can we change the systems, so innovators are not hindered in the vital job of utilising the innovation potential in our research and education?	Ideas for piloting
Where can I get help? • How can we provide support functions for innovation, so it is easy to find the help you need?	Ideas for piloting
Innovation - a new inconvenience area? • How can innovation become recognised in the same way as publications, lectures, teaching, etc., and not become an inconvenience area?	Ideas for piloting NTNU
Creating good conditions • How can we best define the "right" conditions for innovation at all levels within our three areas of responsibility (teaching, innovation and research)?	Not a prioritisation now
For who? • How to increase engagement and better target knowledge we develop to become more accurate and solve real needs?	Ideas for piloting
'Assignment sustainability' needs innovation • How can we get interdisciplinary collaboration between relevant actors where everyone's interests are met while providing a fertile ground for innovations that society needs to achieve the sustainability goals?	Ideas for piloting
Cooperation or a supplier of results? • How can we make sure that we apply new ways to solve societal challenges (receive funds, etc.)	Ideas for piloting

Equip us - education • How to increase innovation competence and how to make educators able to deliver?	Ideas for piloting
The tower of Babel • How can we ensure that innovation does not become a confusing tribal language but create a common language that everyone understands?	NTNU
Conservatism • How can we become a little more innovative and challenge the established as well as undertake good basic research?	Not a prioritisation now
Downside • How can we change innovation work from something negative to positive?	Not a prioritisation now
Students that can and want • How can we utilise students' ability and motivation to strengthen the innovation climate at the faculty?	Not a prioritisation now
Celebrate failure • How to create a culture where errors and failures are accepted? A place where employees dare to take risks and develop Edison's attitude to failure?	Not a prioritisation now

3.3   Focus on future studies at NTNU

There is much work going on designing future studies at NTNU. This includes several major development projects: Technology studies, HUMSAM studies (humanities and social sciences), and RETHOS (National Guidelines for Health and Social Sciences Education). The first two are initiated by NTNU, while the government initiated RETHOS via the Ministry of Education and Research. How is innovation and collaboration with working life included in these development projects? We will present the status for all three. Finally, the ongoing mapping of non-compulsory practical training activities in different study programs at NTNU, managed by the RSAs, will be presented (before mentioned in section 2.5).

In October 2019, NTNU RSAs and the groups in charge of "Future technology studies", "Future HumSam studies", and "RETHOS" arranged a joint workshop. The goal was to provide detailed guidance covering relevant challenges and opportunities for good interaction between working life and NTNU and understand what future skills are needed to promote lifelong learning. The work resulted in 11 recommendations (see table 3) which will be included in developing future studies at NTNU.

Table 3: Recommendations from the RSA workshop at NTNU

The main essence of the discussions in the NTNU RSA workshop summarized in 11 specific recommendations:

Theme: Forms of collaboration and division of work

1. Various practice-oriented measures to enhance work relevance in the studies should be based on **binding agreements at a higher level** than individual companies/businesses and the activities should be included early in the study programs.

2. Scientific staff should be given the opportunity for internships in companies and public enterprises (similar to sabbatical for research).

3. Lifelong learning should be linked to the established threefold cooperation in working life (between employers' organisations, employees' organisations, the state), but should also include the universities – to make it a **fourfold collaboration**.

4. Continuing education should be **offered in many formats**, preferably modularised and **dynamic** to adapt to changes in need and demand.

5. Continuing education should, as far as possible, provide **formal competence**.

Theme: Interdisciplinarity

6. Students should be given **greater flexibility** to choose subjects outside the study programs.

7. Mechanisms for **additional structured competence** ('minor'/supplementary profile) in the study plans.

8. All students should gain experience from **interdisciplinary team work** to develop **cooperation skills**, get to know your personal qualities and see different **career opportunities**.

Theme: Digitization and sustainability as drivers for changing competence needs

9. All studies should provide an (applied) **digitisation competence**.

10. All studies should provide a basic **sustainability competence** based on the **academic context of the education**.

Theme: Other

11. To ensure quality and efficiency, **continuing education should be integrated with basic education**.

3.3.1 Future Technology Studies (FTS)

The project Future Technology Studies aims to support NTNUs study portfolio to align with technology development, societal challenges and business and working life needs from 2025 onwards. The project will develop a recommended framework for NTNUs future study portfolio within technology at bachelor, master and PhD level. The project includes classical technology studies (mainly civil engineering and engineering) and NTNU's studies in natural sciences, architecture, design, and planning. The project's recommendations for these studies must embrace their distinctive character. The perspective of continuing education and lifelong learning must be laid as a basis.

The project will be developed in close contact with the parallel project "Future HumSam Studies" in order to benefit from synergies when possible.

In January 2020, FTS conducted an «by-invitation-only» workshop together with working life representatives. The summary from the workshop shows that working life has clear expectations of NTNU when it comes to sustainability, digital competence, multi- and interdisciplinarity, non-technical professionals skills, future professional roles, collaboration models between NTNU and working life, continuing education and lifelong learning, innovation and entrepreneurship, and internationalisation.

The FTS project part 1 runs from August 2019 to September 2021. After that, it is expected that the faculties at NTNU develop their study portfolio with the first changes implemented in the academic year 2023/24.

3.3.2 Future HUMSAM Studies

The project "Future HUMSAM Studies" intends to design the next generation HUMSAM studies (humanities and social sciences) at NTNU. This includes strengthening and making visible the HUMSAM studies' contribution to answering major societal challenges, making educational paths and career opportunities visible for future HUMSAM candidates, and supporting and making the working life relevance visible in the HUMSAM studies. The project aims to educate students with a solid disciplinary identity and the ability for interdisciplinary interaction. In a workshop in May 2020, the following overarching question was asked: "How can the HUMSAM educations at NTNU meet the future needs?" Working life relevance was frequently mentioned during the discussions at the workshop, and some central takeaways were: Working life relevance will play an increasingly important role for future HUMSAM studies; it is crucial to have the ability to communicate and be proud of your subject; there is an untapped potential for better interaction with the outside world.

As of November 2020, the HUMSAM project has completed a provisional report from the project's first phase. One of the proposed development paths across all HUMSAM disciplines is closer collaboration with working life (NTNU 2020).

3.3.3 RETHOS

Future Technology Studies and Future HUMSAM Studies are projects that are under development and where the recommendations are not implemented yet. RETHOS - National Guidelines for Health and Social Sciences Educations - on the other hand, has come further in their process. RETHOS aims to ensure that the educations are future-oriented and in line with the competence needs of the health and welfare services and users' needs. National regulations on a joint framework for health and social sciences educations was implemented in September 2017 and applied to universities and university colleges that offer education in health and social sciences. Twelve shared learning outcome descriptions are designed, and

these apply from the academic year 2020-2021[1]. Learning outcome description, no. 11 deals with the importance of innovation: "The candidate knows about innovation processes and can contribute to service innovation and systematic and quality-improving work processes".

Extensive work is underway at various university colleges and universities to implement the learning outcome descriptions associated with RETHOS in the relevant study programs. At the Faculty of Medicine and Health Sciences (MH), NTNU, a mapping of learning activities that can contribute to meeting learning outcome number 11, have been conducted. Some study programs already have suitable teaching activities, while others have to work on developing such. One example of an existing teaching activity contributing to Learning outcome no. 11 is the nursing education in Trondheim which has an innovation camp in the third year of study in collaboration with "Young Entrepreneurship". The innovation camp is both an idea competition and a learning platform for creativity and innovation. Students are challenged to come up with possible solutions to real challenges from the health sector[2]. Several of the three-year profession-oriented study programs participate in similar interdisciplinary innovation camps. Students come up with the best possible solution to a real challenge provided by an external client during a limited period. Young Entrepreneurship assists in several innovation camps at NTNU, for example, an interdisciplinary innovation camp for the bachelor's programs in bioengineering, computer engineer and radiography in campus Trondheim, and the bachelor's programs in bioengineering, biotechnology and bio marine innovation in campus Ålesund.

To provide teachers with a toolbox for learning activities associated with learning outcome no. 11, the MH faculty collaborates with the Center for excellent teaching (SFU) ENGAGE[3] and innovation leaders at NTNU. One also finds learning activities associated with RETHOS in the project LOVU that the University of South-Eastern Norway (USN) manages. LOVU is a learning and assessment hub for joint learning outcomes involving health and social sciences educations. The project focuses on cohesive teaching, flipped classroom and collaborative learning using student-active learning and forms of assessment[4].

3.3.4　Mapping of work experience integrated in studies at NTNU

The mapping mentioned above that the RSAs have initiated at NTNU is about to be completed in a report. The report is based on interviews with about 40 department heads, study program leaders and course coordinators from all NTNUs faculties (except the University Museum). The mapping reveals that NTNU is characterized by great width in how collaboration between study programs and working life is structured. In addition, there is considerable variation in how the various forms of collaboration are practised. For example, guest lectures are conducted very differently. One of the main findings from the mapping is a considerable variation in the terminology used to describe how the cooperation between working life and education functions. The variations are so significant that one can argue that NTNU has a terminology barrier and a need for translation between different departments. This is also connected with another core finding: There is little discussion and exchange of experience across study programs and departments. The survey shows that a lot of the collaboration between

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1 https://lovdata.no/dokument/SF/forskrift/2017-09-06-1353?q=helse-%20og%20sosialfag%20l%C3%A6ringsutbytte
2 https://www.midtnorskdebatt.no/meninger/kronikker/2018/08/22/Helsesektoren-trenger-nye-og-gode-l%C3%B8sninger-17367087.ece
3 https://www.ntnu.edu/engage
4 https://edu.usn.no/prosjekter/lovu-larings-og-vurderingsbank-for-felles-laringsutbytter-for-helse-og-sosialfagutdanningene-article227556-32394.html)

studies and working life has been founded on a fragile foundation with few but very passionate individuals. If these individuals disappear, so does the network for collaboration. There is a need for a more systematic and clear recognition of such initiatives in order to facilitate cooperation between studies and working life.

Not entirely unexpected was the lack of resources highlighted as the main barrier to more cooperation. Be it lack of time, earmarked positions, finances, incentives, or space and occasion for professional sharing of experiences and discussing collaboration opportunities. It is unmotivating to create collaboration when this does not give the educators credit in any way.

3.4 Innovation in SFIs and FMEs

NTNU has several research and innovation centres, for example SFIs (Center for Research-Driven Innovation) and FMEs (Research Centers for environmentally friendly energy).

SFI

Centre for research-driven innovation (SFI) is the Norwegian Research Council's scheme to build up or strengthen Norwegian research environments that work closely with innovative businesses. NTNU is at the time of writing (autumn 2020) host for 12 SFI centres and partners in 14[5]. NTNU were assigned 5 new SFIs in June 2020: "SFI Autoship - Autonomous ships", "Norwegian Center for Cybersecurity in Critical Sectors (NORCICS)", "SFI Norwegian Center for Research-Based Artificial Intelligence Innovation (CRAI)", "SFI Center for Geophysical Forecasting – CGF", and "SFI PhysMet".

The Research Council has the following description of SFIs: "The centres for research-driven innovation (SFI) develops competence that is important for innovation and value creation. Long-term research in close collaboration between R&D-active companies and prominent research environments will strengthen technology transfer, internationalization and education of researchers. Scientific

quality in research must be at a high international level. The centres are established for one period of a maximum of eight years (5 + 3)"[6].

We will in the following refer to evaluations of the SFIs as such and not go into specific assessments of NTNUs SFIs. The SFI concept was assessed in 2018 by analysts from DAMVAD Analytics, Cambridge University and Rand Europe[7]. They concluded that the SFIs were an important tool that contributes to high research quality but that the scheme also has several areas of improvement. Former Minister of State Iselin Nybø underlined that the report recommended a stronger focus from the SFIs towards solving major societal challenges[8].

All SFIs undergo a compulsory mid-term evaluation where further financing of the centres is decided. The evaluation also serves to provide feedback on elements where the centres have room for improvement. Four experts submitted a report in 2019 on commission by the Research Council of Norway as a part of the mid-term evaluation of the 17 SFIs that received

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5 https://www.ntnu.no/forskning/sf
6 https://www.forskningsradet.no/om-forskningsradet/programmer/sfi/
7 https://www.forskningsradet.no/siteassets/publikasjoner/evaluation_of_the_scheme_for-_research-based_innovation_sfi.pdf
8 https://khrono.no/sfi-innovasjon-forskningsradet/evaluering-sentre-for-innovasjon-ma-lose-flere-samfunnsproblemer/216929

funding from the third call[9]. In addition to specific feedback to the centres, the report contained 12 recommendations to the Research Council on improving the program.

In the mentioned mid-term evaluation from 2019, the various SFI centres are challenged to collaborate more on, for example, joint doctoral projects, and it is encouraged to increase cooperation with the foreseen users of the knowledge that is developed. Further, it is proposed that the Research Council work with the centres to improve the industrial understanding and experiences of the doctoral students working in the centres.

The DAMVAD report from 2018 and the mid-term evaluation report from 2019 pointed out that the SFIs deliver high-quality research but can be even better at collaboration with industry, a higher degree of commercialisation of research results, and more focus on innovation and value creation. The employees affiliated with the SFIs are still obligated to deliver on indicators like research and teaching to pursue an academic career and position themselves in the competition for promotion. Cooperation with working life and industry, together with tangible value creation and societal benefit of the research, should have higher significance concerning merit and incentives.

FME
The FMEs work with long-term research aimed at renewable energy, energy efficiency, CO2 management, and social science aspects of energy research[10]. The centres should have the potential for innovation and value creation, and the research takes place in close collaboration between research environments, industry and funding partners. In the last ten years, the Research Council have handed out more than 4 billion NOK for research toward environmentally friendly projects

through significant investments in energy research programs (RENERGI/ENERGIX), CO2 management program (CLIMIT) and research centres for environmentally friendly energy (FME).

In 2018, a study investigated the realised and potential effects connected to Norwegian energy research. Impello Management and Menon Economics conducted the study in collaboration with eight FMEs: FME HighEFF, FME ZEN, FME HydroCen, FME CINELDI, FME SuSolTech, FME Bio4Fuels, FME NCCS of FME MOZEES. The results are described in the report "Effects of energy research" (Iglebæk et al., 2018). In 2018 the expert group "FME Innovation Task Force" was appointed by SINTEF (a Norwegian research institute) and NTNU Energi to make recommendations for innovation work in the FME centres. The result from the group "FME Innovation Task Force" is the report "Innovation in the FMEs" (Størset et al., 2018), which summarises the work and gives five tips to increase innovation from The FMEs. The advice focusses on the need for strong leadership, to develop a separate plan to build an innovation culture at each centre, to have a dedicated resource to follow up the project, to use tools to systematise and value ideas and innovations, and to show the societal benefits of the innovations.

In 2019, the FME innovation Leader Forum was established. This follows up the work from "FME Innovation Task Force" (Størset et al. 2018) and the effect study from Norwegian energy research (Iglebæk et al. 2018). The FMEs involved are ZEN, NTRANS, HydroCen, Bio4fuels, CINELDI, HighEFF, MoZEES, NCCS and SUSOLTECH. One of the results from work in 2019 was the report "Innovation work in the FMEs" (Nuijten et al., 2020). This describes how ZEN, NTRANS, HydroCen, CINELDI HighEFF, NCCS and SUSOLTECH work with innovation. Several FMEs have pilot projects and

9 https://www.forskningsradet.no/siteassets/publikasjoner/midway-evaluation-of-17-centres-for-research-based-innovation-sfi-iii.pdf
10 https://www.forskningsradet.no/en/apply-for-funding/funding-from-the-research-council/fme

pilot areas where innovations are tested and demonstrated, contributing to visualising the FMEs innovations. Several have systems for registering and reporting the innovations in an annual status report or innovation report. Some examples:

FME ZEN (www.fmezen.no) uses an innovation registration system (Excel spreadsheets) and registers, among other things, the following information per idea/innovation: Number on the TRL scale[11] (each year), type of innovation, who is involved, a description of the idea, market potential and potential impact. The registration system is updated two times a year, and at the same time, they set objectives for the next six months related to increasing the TRL and how the idea can reach the market in the form of socially beneficial products or services. Ideas at FME ZEN must be reported in an annual ZEN innovation report.

FME NTRANS (www.ntrans.no) started up in the autumn of 2019. The results from CENSES, which is the precursor to NTRANS, is gathered in the CENSES Innovation study that was completed at the centre's end: https://www.ntnu.no/web/censes/viktigste-funn. The innovation work at NTRANS will build on the work from CENSES Innovation study. NTRANS undertake annual status reports in order to develop further knowledge and internal discussion of goal achievement for innovation.

HighEFF (www.higheff.no) registers all innovations. When innovations are registered at HighEFF they evaluate the probability of success and potential impact. If both of these indicators are high, there is an ambition to put extra effort in continued development. Every year, the management reviews new ideas/innovations and updates those already registered and under development.

In NCCS (www.sintef.no/nccs), task leaders define possible innovations in the annual work plans and this is followed up throughout the year and in the annual reporting. They have established a framework for mapping innovations where they document the innovations associated with what types of innovation, degree of maturity, and what effects the innovation may have, and for whom. The framework makes it easier to understand and communicate the amplitude of innovation the FME creates and how it best impacts society, industrial actors, further research work, etc.

Innovations in the FME centre **SUSOLTECH** (www.susoltech.no) are mapped during working meetings within work packages and through reporting progress indicators. In this context, the «Solar Industry Forum», which is held several times each year, has been a helpful tool to follow up and concretise the innovation work.

3.5   Artistic development work

Artistic development work is equal with research in the Universities and University Colleges Act. As of now, artistic development work is not included in the scheme for performance-based financing, mainly due to challenges with developing a system for documentation and visibility

of results of artistic development work. Artistic development work has many shared features with innovation. It is a diverse phenomenon that can be difficult to capture and document using established parameters. Several national and international processes are underway

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11 The TRL (Technology Readiness Level) scale describes technology maturity. This scale says something about how far you have entered into the development process and what documentation is available for the technology's performance.

that focus on the registration and visibility of artistic development work in order to better document, archive, and facilitate merits for both professional environments and individuals. Ongoing processes argue for both homogenisation of processes (i.e. finding standard systems and routines across disciplines, and possibly integrated with scientific research) and distinctive systems and practices that take care of the uniqueness of artistic development work. This can be linked to how we look at innovation in the broader sense.

NTNU ARTEC[12] is a heterogeneous group of researchers and artists working within different fields, faculties and departments at NTNU. The group is associated with electronics, telecommunications, design and materials, information science, music, theatre, literature and art. ARTEC's goal is to stimulate interdisciplinary dialogue and innovative research, including artistic research, supporting and producing creative practices, and exploring and establishing new forms of knowledge creation, sharing, and dissemination. There are three prominent examples of how ARTEC works with visibility of their activities:

firstly, the coordination of NTNUs involvement with "Adressaparken" as a place for art, research, exhibition and community involvement, secondly the collaboration with "Kunsthall Trondheim", and thirdly the collaboration with Technoport. The "Addresseparken" is an outdoor space that becomes a living laboratory for research and innovation, testing new solutions, an arena for public debate and knowledge dissemination connected to art and technology. The technological infrastructure in "Adressaparken" is a collaboration between Adresseavisen (newspaper in Trondheim), Trondheim municipality and NTNU. Technoport is another important dissemination arena for NTNU ARTEC. It is an organisation that stimulates science-based, technological innovation and is an arena for interdisciplinary collaboration between academia, business, industry and the public sector. ARTEC has been a significant contributor to Technoport's events. NTNU ARTEC's professional environments also arrange NTNUs Artistic Research Week, an essential ingredient in making research visible and exploring the interplay between art and technology across disciplines and research traditions.

3.6   Working life relevance through industrial cases in the natural sciences

Recruiting students is important, but students must also complete their degrees and become relevant workers in the society. Dropouts from study programs are generally high at the beginning of the studies. The business/industry forum "Collaboration forum" at the Faculty of Natural Sciences wanted to decrease the drop-out rate. Through connecting students with interesting working life-relevant cases early in the studies, the goal was to make students more motivated to complete. The "Collaboration forum"

expanded its mandate from only focusing on recruitment to now also focus on working life relevance during the studies. After a workshop addressing working life relevance in 2019, Collaboration forum started up the project "Waste to value", where the goal was to establish meeting arenas between working life, students and teachers. The first activity was a pilot related to training and implementing industrial cases through collaboration with industry players. SFU Engage[13] has also contributed with necessary expertise.

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12 https://www.ntnu.edu/artec
13 SFU Engage is a Center for Excellence in Education

A workshop was arranged between the companies Elkem, Hydro and Borregård in the spring of 2020. Teachers in chemistry, physics, chemical process technology, thermodynamics and materials technology was also present. The companies presented their projects within the theme «Waste to value» to develop relevant cases for different educational programs. Teachers have assessed which subjects the cases are best suited for, and the cases are further developed in collaboration with industry partners and SFU Engage. The industrial cases are implemented in courses early in the studies, where surveys have shown that students experience low working life relevance[14] and the drop-out rate is high. Through these efforts Collaboration forum establishes interaction arenas between the three parties working life, students and educators, to increase the societal relevance. In 2020, a large and successful recruitment activity to get more applicants for the chemistry educations was undertaken. It is therefore extra vital to deliver on working life relevance so that students' as well as relevant employers' expectations are met.

3.7 Focus on Health Innovators at the Faculty of Medicine and Health Sciences

The Health Innovator School[15] (HI School) is an initiative from the University of Oslo (UiO), with NTNU in Trondheim and Karolinska Institutet (KI) in Stockholm as partners since 2016. From 2020, Copenhagen University will also be included in the partnership. The concept has therefore become a Nordic initiative. The main goals of the HI school are to develop innovative culture and mindset, to equip researchers with new knowledge and innovation tools, establish new companies based on research, and bring ideas and talents from research into existing companies, industry, and businesses.

The HI school consists of three different courses, which is repeated annually. Courses 1 and 2 have PhD students, researchers/postdocs and clinicians as their target group. Course 1, "Health Innovation and entrepreneurship", focuses on commercialising research-based ideas and how innovation can be helpful in clinical contexts. Course 2, "Entrepreneurship in the health care system", provides insight into the support apparatus for health innovators and contains a mentoring scheme for developing ideas for commercialisation. Course 3, "Health Innovation School for Professors", has participants with leadership responsibilities as its target group. Here the focus is on how to combine the role of researcher and innovator and how to increase innovation capacity in the research communities. The HI school has received excellent evaluations and newly received funding from the Novo Nordisk Foundation when Copenhagen university became part of the partnership.

14 www.studiebarometeret.no
15 https://www.med.uio.no/english/research/school-of-health-innovation/about/

04

How to document and make
innovation visible?
Suggestions for action

The insight chapter has shown some examples of working with or thinking around innovation in collaboration with working life at NTNU. Hopefully, the examples can inspire further discussions at NTNU. This latter chapter will present some measures or suggestions as a basis for further actions. We have grouped the suggestions under three headings: Organizational measures and culture building, Merit, Specific recommendations.

4.1 Organizational measures and culture building

"Project innovation climate"; Can be carried out as a whole or in pieces at different places in the organisation. The NV faculty has led an extensive design-driven innovation project. Similar projects can be carried out, partly or as a whole, elsewhere in the organisation, at an institute or in smaller groups. Such projects can work well to map the ecosystem, get an overview of concrete activity, and understand better motivation and interest concerning innovation. Such projects contribute to creating an innovative "mindset" in those who participate, making them better equipped to promote or support innovation.

Common arenas for innovation
The evaluation of the SKI program points out that the program's role as a shared network and learning arena across units at NTNU is essential. The potential to spread insights beyond the units where the innovation leaders and recipients of innovation scholarship are employed is considered significant. Common arenas facilitate sharing concerning how to work with innovation, document or make innovation activities visible. Such arenas could be both formal and informal and based on interdisciplinarity, knowledge transfer and experience sharing. Such arenas can include - breakfast meetings, short seminars and panel debates that address various issues. Maybe different actors can be responsible in turn, for example departments, academic groups, centres, or faculties. Those who are responsible must be motivated. If not, it becomes an empty structure.

4.2 Merits

We have seen that finding time and space to work with innovation as a scientific employee at NTNU is challenging. Innovation as a career path is complex. Based on the insight we have gained, we recommend some areas that we believe needs more work.

Focus on time and time resources
The insight chapter has a key finding that emerges in interviews with the leaders, in the Innovation Climate project, and is mentioned in the mapping project initiated by the RSAs: It is challenging to find time for innovation for scientific staff at NTNU. Teaching assignments and research have the most prominent focus and fit well into an hourly budget at an institute or academic group. Innovation and collaboration with working life is for many experienced as something done "in addition". Some leaders also see this as an evident concern, and they experience that employees are under much pressure with a series of tasks to be solved.

The working group proposes that NTNU look closer into this particular situation. We

see from our work that this tension can be experienced as a barrier to innovation and create a situation with increased pressure towards those individuals with an extra passion for innovation who will engage in innovation even when there is no time set aside.

Innovation competence in applications for full professorship
Innovation is a core task in NTNUs strategy and is one of the tasks required to carry out NTNUs broad societal mission. How is the opportunity for an associate professor seeking promotion to full professor to prioritise innovation and collaboration with working life when this is not clearly anchored in the job structure and a career path? The insight chapter has shown that this is a crucial issue.

In 2018, national regulations concerning employment and promotion in teaching and research positions were revised. One of the changes concerns the pedagogical requirements for associate professors and full professors. A pedagogical portfolio is recommended to make pedagogical competence visible in a promotion application. This corresponds to the competence in the piloted pedagogical merit system at UiT and NTNU[1]. One can argue that innovation competence and cooperation with working life should also be documented to incorporate the universities broad societal mission and that this type of competence should be included in the pedagogical portfolio in relation to teaching. Innovation competence linked to research projects can be made visible in the CV together with research projects, publications, supervisor experience and dissemination competence.

4.3 Specific recommendations

Incentives
NTNU has seven internal prizes to recognise employees who promote NTNUs strategy "Knowledge for a better world". This includes the award for "Innovation and collaboration with working life"[2]. This prize is essential to preserve. The working group believes it is important to highlight that innovation takes place in professional and academic communities and that a price in this area should be awarded to groups that work together. The award for "Innovation and collaboration with working life" consists of a diploma, a scholarship of 25,000 NOK, and a work of art. The working group will emphasise the importance that the award still consisting of one allocation of money that stimulates further

innovation work. Maybe prices in different formats can also be established at the faculty level where appropriate?

The interviews with the leaders showed that financial incentives for innovation are far between. This can be due to financial limitations. Some describe local celebrations if someone succeeds with a business establishment or similar activities. Such measures can help build an innovation culture.

Channels for documentation and visibility
Work to increase innovation and the societal impact should be disseminated, documented, and registered. This requires

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1 NTNU's system for educational merit has been evaluated. The evaluation report (Raaheim et al 2020) concludes that the scheme has not yet found its place in the institution's ongoing quality work. The following recommendations are given: The information work must be strengthened, it must be clear how the scheme is part of NTNU's overall strategy, the department heads must be mobilized, the criteria must be clearer, feedback routines and the actual feedback to applicants must be improved, the scheme should include all positions involving teaching.
2 https://innsida.ntnu.no/wiki/-/wiki/Norsk/Interne+priser+til+ansatte#section-Interne+priser+til+ansatte-Dette+f%C3%A5r+prismottak-erne

channels that are equal to scientific publications for research results. Here it is not easy to manoeuvre as a scientific employee.

Research has good established channels and procedures to follow, but channels for work related to innovation and societal effect are limited. Cristin (Current Research Information System in Norway) is the registration channel that NTNU uses for publications and other types of output from research. The system is not tailored to either innovation, interdisciplinary work, sustainability research or research on systems. Looking at the choice of science disciplines when registering, one has only the following options: humanities, social sciences, mathematics and science, technology, medical subjects and agricultural and fisheries subjects. There is a need for a discussion related to how such a registration system can correspond to society's need for research, innovation and the overall societal mission of the universities.

The working group recommends the following: 1) increased awareness about which channels are suitable for documenting and communicating different types of innovation activity, preferably through a mapping of different alternatives, 2) that some of the existing dissemination channels can be further developed also to include innovation activities (e.g. Læringsfestivalen), 3) establishing new channels (Open Access) that stimulates and contributes to ensure that innovation work is disseminated, documented and registered.

Table 4: Summary of the working group's recommendations

Measures/proposals	Challenge/justification
"Project innovation climate"; Can be implemented partly or as a whole at different organisational levels at NTNU	An approach to start a discussion about innovation, this includes outlining existing activity and mapping potential activity. It can be a key to map, uncover, and look ahead.
Common space or arena for innovation	Ensure that work on innovation is widely spread, and facilitate critical discussions.
Focus on time and time resources	Innovation activity and collaboration with working life is not systematically given room or acknowledged when calculating working time in scientific positions. When it is not appropriately incorporated, it is difficult to provide such activity status.
Innovation competence in applications for full professorship	It is unclear if and in what form innovation activity can be included in the present system.
Incentives	Incentives can help make innovation activity and collaboration with working life visible. It can encourage further efforts and build a culture that recognises such activity.
Channels for documentation and visibility	There is a need for different communication channels to document and make visible work concerning innovation.

Final remarks

As pointed out in this report, there are many approaches to innovation in the large organisation that NTNU is. The working group sees it as essential to preserve this diversity.

NTNU, as a diverse university, has many tasks and a broad social mission. Some professional environments define themselves as contributors to innovation, while this is not as pronounced in other professional environments. This variation is likely to continue. However, what is important is to ensure that NTNU has an active debate and reflect on the types of knowledge and different competencies that employees and students need to fulfil NTNUs overall vision "Knowledge for a better world".

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APPENDIX 1: RANKINGS: MOST INNOVATIVE UNIVERSITIES IN EUROPE AND THE WORLD

Stanford University in the US was No. 1 on Reuters' top 100 list of the most innovative universities in the world in 2019, for the fifth year in a row, followed by MIT in the US (No. 2), Harvard in the US (No. 3), the University of Pennsylvania (No. 4), and the University of Washington (No. 5). The highest located European universities are KU Leuven in Belgium (No. 7), Imperial College London in the United Kingdom (No. 10) and the University of Erlangen Nuremberg in Germany (No. 14). It is 46 universities from the USA in the top 100, 9 from Germany, 8 from France, 6 from Japan, South Korea and the United Kingdom, 4 from China, 3 from the Netherlands and Switzerland, 2 from Belgium, Canada, Israel and Singapore and 1 from Denmark.

In 2019, for the fourth year in a row, KU Leuven in Belgium was No. 1 on Reuters' top 100 list of the most innovative universities in Europe. Criteria for the list are the number of patents, success rate and commercial impact. NTNU was No. 56 on Reuters' top 100 list. German universities are in the top 100 with 23 institutions, followed by the United Kingdom with 21 universities, France with 18, the Netherlands with 9, Belgium with 7, Spain and Switzerland with 5, Italy with 4, Denmark with 3, Norway with two and Austria and Ireland with 1. German and Dutch universities are rising on average, British universities are showing a decline.

Table 5. 'Reuters Top 100, Europe's Most Innovative Universities 2019', number 1-10 and 56 (NTNU), based on: https://graphics.reuters.com/ EUROPEUNIVERSITYINNOVATION/010091N02HR/index.html

Number	University	Country	Students	Total patents filed*	Succes rate (%)**	Commercial impact score***
1	KU Leuven	Belgium	56,351	305	40.0	43.3
2	University of Erlangen Nuremberg	Germany	38,771	238	52.1	51.2
3	Imperial College London	United Kingdom	15,317	317	33.4	34.4
4	University of Cambridge	United Kingdom	18,977	207	38.6	31.4
5	EPFL - Swiss Federal Institute of Technology Lausanne	Switzerland	9,750	235	39.6	58.1
6	University College London	United Kingdom	38,000	240	30.0	38,4
7	Technical University of Munich	Germany	41,375	191	40.8	40.5

8	University of Manchester	United Kingdom	34,469	133	29.3	28.0
9	Universiteit of Zurich	Switzerland	26,042	167	34.1	35.8
10	Swiss Federal Institute of Technology Zurich	Switzerland	21,397	305	29.5	42.7
...						
56	Norwegian University of Science & Technology	Norway	42,031	56	39.3	15.6

* Number of basic patents (patent families) filed by the institution between 2012 and 2017
** Ratio of patents filed by the institution between 2012 and 2017 that were subsequently granted by patent offices
*** Indicator of how often basic research originating at an institution has influenced commercial R&D activity, as measured by academic papers cited in patent filings. Higher scores are better.

The most innovative universities in the world stimulate innovation by focusing on entrepreneurship, creating a culture of innovative thinking, encouraging collaboration with the private sector, promoting diversity and inclusion, and exploring technology and societal needs. They invest in research and development that support creativity. They also have long-term cooperation with the private sector where they, e.g. take the role of an innovation centre that develops and tests new technologies. This type of collaboration is beneficial for universities and the private sector.

KU Leuven in Belgium (No. 1 in the top 100 in Europe) has produced a large number of patents and articles that influence researchers in Europe and the world. KU Leuven Research & Development (LRD) was established in 1972 and was one of the first "tech transfer offices" in Europe. They have contributed to more than 124 spin-off companies across a variety of industries. In the period 2012- 2017, 305 patents were filed, of which 146 in 2017, and more than 2,000 new agreements for contracts and research collaboration were established per year. In Belgium, an Industrial Research Fund (IOF) creates value for industry and society and influences people's lives by facilitating knowledge transfer, creating innovative solutions, applying research results, and strengthening the link between basic research and technological innovation. IOF budget was 32,896k € in 2018. KU Leuven received 15,103 k € (46% of the budget). The annual distribution of IOF is based on a calculated distribution key including the following: doctoral degrees, publications and citations (weighting factor: 0.10), industry contacts (0.30), EU projects (0.20), patents (0.20) and spin-off companies (0.20). KU Leuven employs 35 innovation leaders and two central coordination officers. The role of the innovation leaders is to identify new cases, identify "valorisation trajectories", apply for financing programs, develop the valorisation strategy, business development, take a leading role in contracts with industry, networking, creating visibility, project management and coordinating the valorisation of research results.