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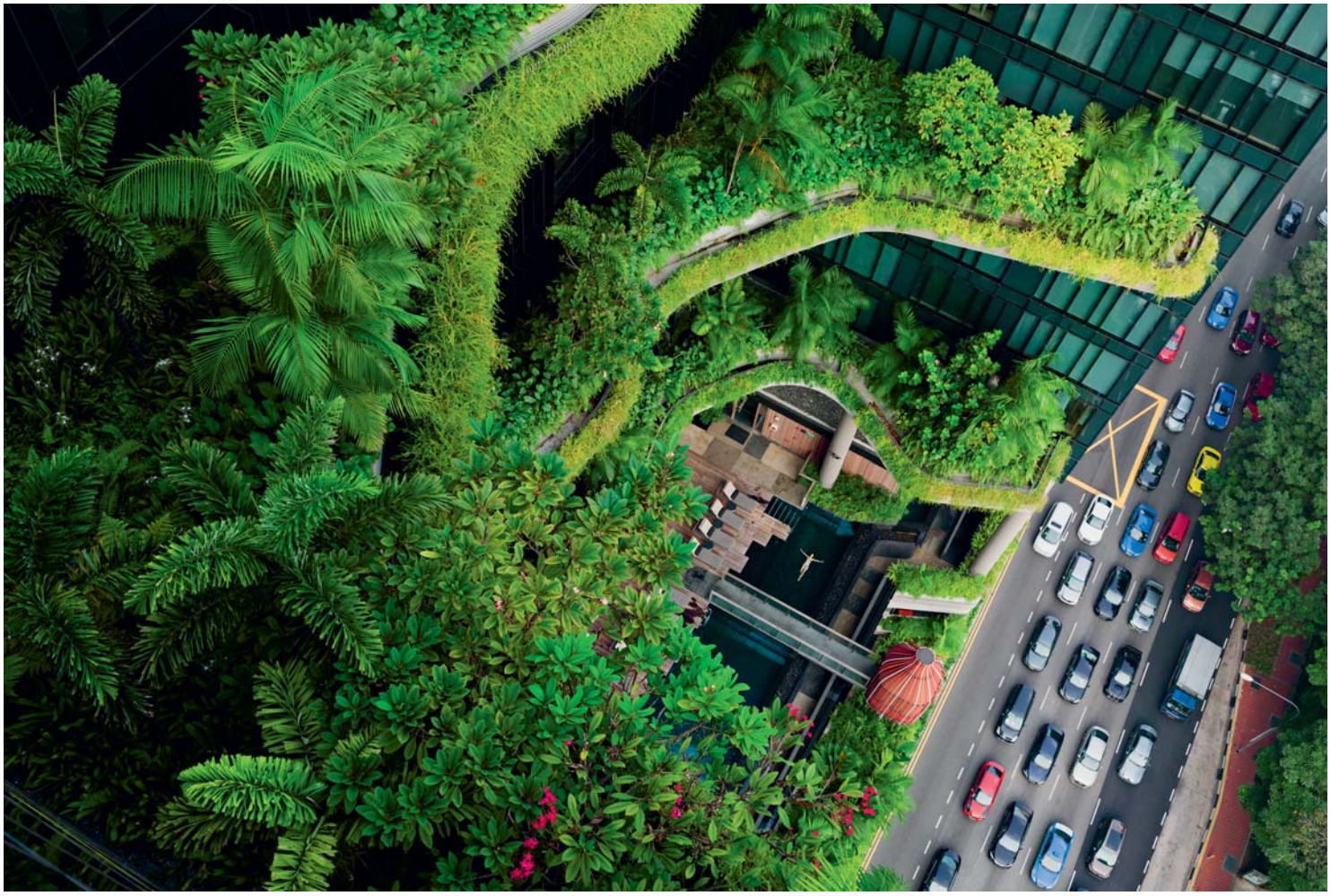

- BIODIVERSITÄTSMONITORING
- CO_2-BEPREISUNG UND GERECHTIGKEIT
- ANALYSING THE *LIMITS TO GROWTH* MODEL

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Science-policy boundary work by early-stage researchers

Recommendations for teaching, internships and knowledge transfer

Establishing mechanisms for involving scientists in policymaking for the Sustainable Development Goals (SDGs) *is a long-term requirement. The Zurich-Basel PhD program* Science and Policy *involves early-stage scientists in science-policy boundary work through internships and co-supervision at academic and policy institutions. In a Delphi study, students reported to have acquired new skill sets for science-policy dialogue. However, challenges remain, including the lack of time for policy work during a PhD project or the different incentive systems in academia and policy.*

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Science-policy boundary work by early-stage researchers. Recommendations for teaching, internships and knowledge transfer
GAIA 28/3 (2019): 310–315 | **Keywords:** curriculum, Delphi study, evaluation, internships, policy training for early-stage researchers, science-policy boundary work, science-policy PhD program, transdisciplinary teaching

The need for science and policy education

A unique PhD program *Science and Policy*[1] for natural scientists at ETH Zurich (Departments of Environmental Systems Science, D-USYS; Biology, D-BIOL; Earth Sciences, D-ERDW) and the Universities of Zurich and Basel has been offered by the Zurich-Basel Plant Science Center (PSC) since 2010. Disciplinary backgrounds of participants are various: for example, plant sciences, ecology, biochemistry, earth sciences, geography, sustainable land use, food sciences, climate sciences, and personalized health. The program prepares PhD students for science-policy boundary work through competence-oriented transdisciplinary teaching. It enables early-stage scientists to engage with policymakers and stakeholders and to support social, economic, technological and ecological changes along sustainable development lines with research evidence.

Scientific evidence is necessary to contribute to the development of policy options. The difficulties of implementing scientific evidence into policymaking for sustainability have long been recognized and are part of boundary work at the science-policy interface (Jasanoff 1987). Bridging the science-policy boundary can be difficult, as policymakers can ask scientists for evidence, but will themselves decide on additional factors such as electoral power or cost-benefit considerations (Messerli et al. 2015). Science and technology drive changes in society, but current social transformation is linked to an erosion of the legitimacy of institutions as well as experts. Therefore, scientists need to act as intermediaries between science, policy and society (Felt et al. 2013).

A new generation of researchers in the natural sciences is necessary. This requires nurturing through educational programs. Scientists should be able to participate and become accountable at the science-policy boundary. We believe that early-stage researchers in the natural sciences should learn about their roles and how to integrate science in the policymaking process through formal training and mentoring, as well as internships in policy institutions (Godfrey et al. 2010). Especially policy internships provide opportunities to learn how science affects policymaking in practice. Interns develop awareness of policy processes, foster relationships, build networks, and explore career options (Gual Soler et al. 2017).

The PSC was founded in 1998 to support the plant science research community. Currently counting more than 500 members, the PSC supports interdisciplinary research in plant sciences from molecular to ecosystem levels, as well as platforms for dialogue with the public and unique educational programs for early-stage scientists.

In this paper we will first introduce the educational framework used for teaching

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1 *https://www.plantsciences.uzh.ch/en/teaching/phdsciencepolicy.html*

TABLE 1: Educational objectives of the PhD program *Science and Policy*. Early-stage researchers in the natural sciences develop concepts and competencies in the dimensions of knowledge, attitude and action.

DIMENSIONS	COMPETENCIES AND CONCEPTS DEVELOPED. EARLY-STAGE RESEARCHERS WILL:
scientific knowledge	■ build scientific knowledge in the context of participants' discipline
knowledge of political system	■ understand policymaking processes and policy culture ■ recognize polity, politics and policy as part of the political system ■ interact with these elements ■ learn various ways science impacts policy
develop attitude	■ define roles of scientists in science-policy boundary work; act accordingly ■ know the norms of science-policy boundary work: credibility, salience, legitimation toward science, policy and public, and apply them in practice ■ respond to the values and needs of policymakers and society and appreciate all those engaged with a problem as both producers and users of knowledge ■ develop an attitude of social learning; reflect with stakeholders and policymakers on the use of evidence in policy options
be able to act in policymaking	■ recognize different stages in the policy cycle. Know how scientific evidence is useful in each stage; be able to apply methods to interact with these stages ■ present findings in policy-friendly formats ■ develop participatory skills ■ contribute unique skill sets (participatory skills, communication skills, incl. risk and uncertainty communication, scenario building and modeling, skills for impact generation) and expertise to policymaking ■ engage in dialogue about policy options with the public, stakeholders and policymakers in inclusive environments

science-policy boundary work at PhD level. Secondly, we will describe the co-supervision and internships provided at policy institutions. Thirdly, we will share lessons learned so far, and especially during a Delphi survey, which included policy partners, academic supervisors, lecturers, experts, fellows and alumni. Fourthly, we provide recommendations for other persons and institutions that are involved in science-policy boundary work with early-stage scientists.

Boundary work and mentoring through internships and co-supervision make demands on all participants with regard to resources, knowledge and collaboration. Identification of success factors, as well as barriers, brings continuous improvement to training and mentoring and to the creation of environments for productive engagement of early-stage scientists.

Educational framework for development of competencies at the science-policy boundary

The PhD program *Science and Policy* offers a three-year curriculum of twelve ECTS[2]. Its thematic pillars are:

- concepts and tools for evidence-based policymaking,
- carrying out stakeholder engagement,
- communicating with the media as important actors in the policymaking process,
- dealing with risks and uncertainties linked to scientific data, models and technologies,
- building scenarios for policymaking
- building political support and understanding decision-making in Swiss and European contexts,
- carrying out policy evaluation with logic models and change theory,
- applying systemic thinking to policymaking.

Professionalization of participants takes place in the dimensions of knowledge, attitude and action, and across the social systems of science and policy. This affects the perception, self-presentation and responsiveness of scientists toward society (table 1). The program aims to strengthen personal traits as described in *Education for Sustainable Development (ESD)*: that is, social learning, cosmopolitan perception, transcultural understanding and cooperation, participatory skills, empathy, understanding for the values of others and reflection on cultural modes (De Haan 2006).

The associated science-policy fellowships: co-supervision and internships in policy institutions

Experiential learning or real-world practice during fellowships enables early-stage scientists to understand the policy environment and how research can be applied to policy and societal questions. PhD students receive co-supervision from academic supervisors and representatives of policy institutions including governmental, non-profit and international organizations. Fellows can complete policy internships of one to ten months at their partner institution. Both internships and co-supervision broaden the PhD students' learning experience through direct involvement in policymaking environments. Interns can work on policy outcomes through contributions to stakeholder meetings, policy briefs, fact sheets, recommendations for practice, or scenarios for deciding on different policy options (figure 1, p. 312).

From 68 students registered between 2010 and 2017 in the PhD program, 32 also had a fellowship. 17 had internships or close collaborations with policy partners: for example, IUCN (CH), Swiss federal offices for the environment and for agriculture (CH), Swiss Biodiversity Forum (CH), Ashoka Trust for Research in Ecology and the Environment (ATREE, India); four out of these are still ongoing. >

2 *www.plantsciences.uzh.ch/en/teaching/phdsciencepolicy/courses.html*

All 13 completed fellowships with policy partners created either highly salient evidence for policymaking (e. g., through scenarios, models, databases and meta-studies) or applications (e. g., DNA barcoding for tracking illegally logged rosewood). Evidence was taken up in the channels of science-policy institutions, policymakers and stakeholders (box 1). In several projects, scientific evidence was especially translated into outputs for policymakers and stakeholders (e. g., into fact sheets or policy reports) or communicated as policy advice through commission work. In some projects, the fellows and their policy partner gave recommendations to farmers and organized farmers' workshops to integrate the results directly in farming practices.

Success factors and barriers for science-policy boundary work in the program

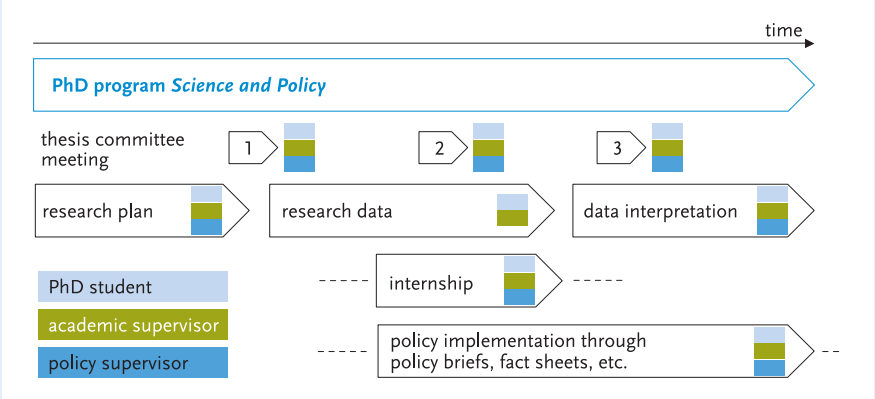
A three-round Delphi survey explored the views of various involved people about the PSC PhD program. In round 1, statements on the benefits of the program and barriers that might hinder science-policy transfer were collected from the individual fellowship reports (20 respondents). Online questionnaires were filled out by 32 (round 2) and 29 respondents (round 3). These were policy partners, fellows, alumni, academic supervisors, lecturers, invited experts, representatives of academic or of policy institutions or people involved in the program in other roles. In round 2, respondents indicated their level of agreement (scale anchors were 1: strongly disagree, 5: strongly agree) with 31 statements from round 1. For round 3, statements from round 2 with average agreement above 3.0 as well as additional statements formulated by participants in free text fields were grouped into five topics: *outcomes, necessary inputs, barriers, limitations* and *recommendations* for the internships. Respondents were asked to rank the statements within each group by importance.

Outcomes of the internships

Respondents rated as the most important outcomes the opportunity to practice science-policy dialogue during internships, the provision of new skills, learning about career opportunities outside academia, and broadening of networks (figure 3a, p. 314). The improved science-policy dialogue was described by one respondent in the first round as follows: internship and collaboration with the policy institution allowed faster identification of knowledge gaps for forest policymaking and hence (re-)orientation of PhD student and "[...] these contacts are much closer and more direct, enabling faster dialogue/more direct transfer of scientific knowledge and information to policy advice." Other respondents emphasized that they „[...] developed a comprehensive understanding and evaluation of the policy landscape [...]" or "the work at [policy institution] offered insight into the matters such a governmental institution has to deal with every day, when it comes to condensing widely spread data into a coherent document for decision-making."

The broadening of science-policy networks was seen as an opportunity to establish collaborations that would continue after the fellowships. One respondent highlighted the role of capacity building for the policy institution in the first round as follows: "Often, capacity is one of the biggest stumbling blocks to advancing key initiatives [...] and while reference is frequently made to the need to forge relationships with academic institutions in order to tap into [scientific] resources, this is one of the few examples of a successful collaboration actually taking place." A policy institution respondent confirmed that they "appreciated the junior scientists' motivation, their flexibility in thinking out of the box, and their investment of time in policy work" (round 1).

FIGURE 1: The structure of the science-policy fellowships within a timeline of four years. Elements with co-supervision from academic and policy supervisors are indicated by color code.



Necessary inputs

Respondents ranked as the main inputs necessary for a successful internship (figure 3b, p. 314): support in transferring analytical skills to real-world problems, in distributing time between research and policy work, and in joint knowledge production.

Barriers and limitations of the science-policy internship program

It was agreed that the lack of sufficient mentoring capacity at both the policy institution and program organizers was a significant barrier (figure 3c, p. 314): "An experienced mentor in policy projects is very important for the feasibility of such projects." "I think that having someone in-house who provides personalized support to the policy-research issues arising within each project would be a great asset for the students" (round 1).

Limitations highlighted by respondents included the restricted time frame for policy work, difficulties in integrating policy work into the research plan, and the different incentive systems in science (publications) and policy (outcomes) (figure 3d, p. 314).

Recommendations

Respondents called for greater flexibility for researchers and partners to adjust the focus and scope of internships (figure 3e, p. 314): "Some processes don't just last from the first day of the month till the end: they are spread over months."

BOX 1: Maintaining biodiversity and managing oil palm expansion – What can policy papers and scenarios achieve? [a]

Oil palm expansion remains an important environmental topic given the large negative impacts it can have on tropical biodiversity (figure 2). John Garcia-Ulloa had developed models and scenarios to understand biodiversity change in oil-palm landscapes under *REDD+* [b] initiatives during his science-policy fellowship from PSC and Mercator Foundation Switzerland within his PhD studies (2011–2016). In 2014, a close collaboration between ETH Zurich and IUCN (International Union for the Conservation of Nature) as a policy partner was established. The main activity within the fellow's internship at IUCN was to convene a group of experts from the oil palm sector to develop guidelines for the protection of biodiversity on oil-palm landscapes for IUCN.

What was the main impact for policy?
The process contributed to the proposal and approval of the IUCN *Resolution WCC-2016-Res-061-EN* in the *World Conservation Congress* in 2016, which allowed the creation of the IUCN *Oil Palm Task Force* and the development of a situation analysis (published as a policy report by Meijaard et al. 2018). The impact of this collaboration has, thus, resulted in a policy resolution by the most important conservation union worldwide, the creation of a formal group of specialists and the publication of the most complete policy report on oil palm and biodiversity to date.

How was the scientific evidence translated into policy outcomes?
The situation analysis was commented and reviewed by 43 organizations and individuals. More than 600 comments from this process were incorporated in the final report. The situation analysis provides a common framework for IUCN and all its members, but as well any other stakeholder, to understand the impacts and implications from oil palm expansion and to find constructive solutions for the sector. After the publication of the report the IUCN task force is looking at developing a similar analysis for the social and economic implications of oil palm development in producing countries.

John Garcia-Ulloa is now a senior scientist at ETH Zurich, where he conducts governance and ecological analysis of oil palm landscapes in the tropics.

FIGURE 2: New oil palm plantings in deforested area.

a See also *https://blogs.ethz.ch/Science_and_Policy/2019/08/20/maintaining-biodiversity-and-managing-oil-palm-expansion*.
b *Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries*, a program under the *United Nations Framework Convention on Climate Change (UNFCCC)*.

Mutual agreement between PhD student, academic supervisor and representatives of policy institution on the scope, goals, stakeholders and methodology of the internship should be established at the very beginning of the fellowship: "I would [...] advise that separate contracts be done with partners (e. g., memorandum of understanding or similar), in order to have a written commitment. [...] Projects with policy partners should be planned way ahead [...]"; and "[policy] objectives should be clear to everybody and agreed on in advance [...]" (round 1).

Conclusions

The deficiency in the uptake of evidence from science by policy is described as the science-policy gap (Owens et al. 2006). The expectation that scientists can push evidence to policymakers through linear translation processes has been questioned for many years (Weiss 1980). Trust, dialogue, exchange and collaboration between both communities are necessary to enable the uptake of science in policy (Godfrey et al. 2010). Preparing early-stage researchers for science-policy boundary work, and embedding them in experiential learning environments through internships, facilitates boundary-crossing in their later work. Participants in the program learned that boundary work at the science-policy interface is characterized by transformation of scientific results in three dimensions: results need to become credible, salient and legitimate for society (Cash et al. 2002). Respondents in the Delphi survey highlighted the opportunities new skill sets and expertise provide for communicating relevant evidence – that is, high-quality research with recommendations linked to the needs of policymakers and society. They ranked as significant limiting factors the time frame available for policy work in the PhD process and the different incentive systems in science and policy settings. These challenges are caused by the different logics of the two systems:

Different incentive systems: Publications requested by the science system rarely contribute to successful policy outcomes as solution to problems. Time-consuming policy work will not be rewarded in the same way as a high-profile scientific publication in the record of early-stage scientists (Rosen 2018).

Different time scales: Scientists should not expect immediate results as the diffusion of science in policy is a long-term process (Rosen 2018). Respondents recommended starting the science-policy dialogue at the beginning of a project and establishing long-term relationships with representatives of policy institutions. The project in box 1 generated research results that started to unfold their highest impact after the end of the PhD with the policy implementation still ongoing. This is consistent with literature: collaboration requires reaching out to policymakers long before research begins, listening closely to their questions and >

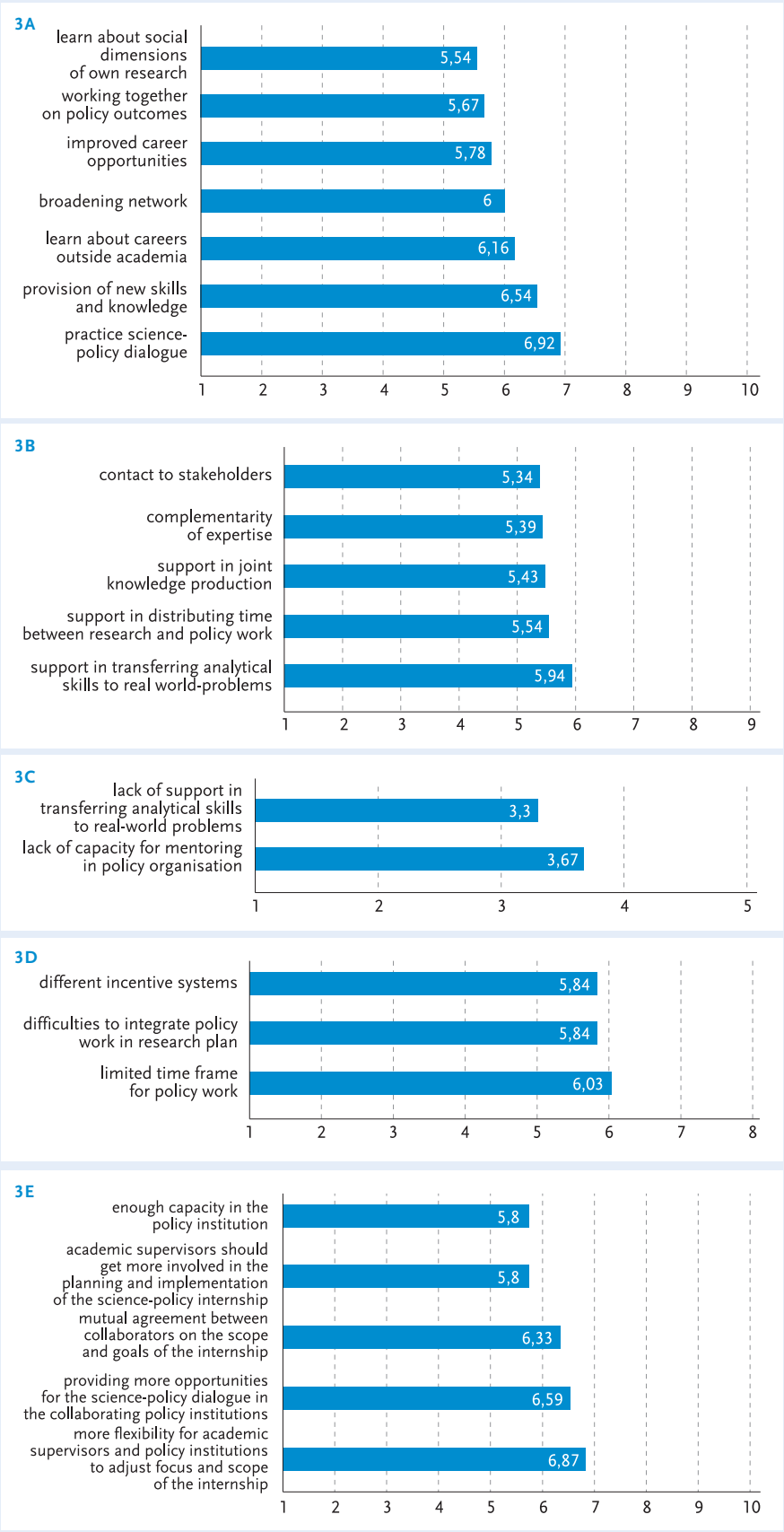


FIGURE 3: Results of round 3 of the Delphi survey: average ranking of statements by increasing importance. **3A.** Outcomes of the internships. **3B.** Necessary inputs. **3C.** Barriers. **3D.** Limitations. **3E.** Recommendations. The number of statements in each group corresponds to the number of possible ranks (x-axis scale). Only statements with average rank > 5.5 (3a, e), > 5 (3b), > 3 (3c) and > 4.5 (3d) are given.

needs, and shaping studies around these (Rosen 2018). This process was followed in some of the science-policy fellowships. Establishing long-term personal contacts with policymakers is a main facilitator in the policy dialogue (Choi et al. 2005).

Different legitimation processes: Credibility of scientific evidence validated within the scientific community does not always correspond with agreement by society. Several authors emphasized the importance of science-policy boundary institutions (ODI 2004, Godfrey et al. 2010, Messerli et al. 2015) for social legitimation.

In sum, fellows experienced challenges and barriers at the science-policy boundary. Researchers and policymakers need to overcome differences in language, priorities, agendas, time scales and reward systems, difficulties in engaging with stakeholders, and at the same time keep research relevant in both systems (ODI 2004).

Recommendations for supporting science-policy boundary work

Based on our own learning processes, we make ten recommendations for boundary work with early-stage researchers. Some of these recommendations (2, 3, 5) need to be targeted by supervising researchers and the policy partners, some need to be targeted or can be facilitated by the organizing program (1, 4, 6, 7, 8) or by the academic institution (9, 10). The PSC training and internship program has already implemented many of these recommendations with currently improving facilitation in 3, 5 and 6 and establishing formats for 7.

1. Time frame for PhD research: The PhD time of four years allows early-stage researchers to generate meaningful research and do policy work. In our experience, to become meaningful the internship with

the policy institutions should not last less than six months. It can be organized in a single block or in flexible periods.

2. Collaboration: New collaborations need time to build trust. Ongoing communication between the partners and regular reflection on the collaborative process is necessary (Vicens and Bourne 2007). Researchers and the policy partner should define their responsibilities at the beginning of the research project by mutual agreement, which can evolve as new ideas arise. Mutual understanding needs to be up-front, so that policy work is considered an important part of science work and vice versa.

3. Define policy-relevant research questions together: Academic supervisors, policy partners and fellows need to focus on joint knowledge production and learning. What is the policy problem? What research question and research design can help find answers and solutions to the policy problem? What is the scope of policy work? Stakeholder engagement is necessary in order to achieve multiple perspectives.

4. Methods and processes of knowledge integration: Transformation of scientific results into policy options is challenging when it comes to articulating results and conclusions, as well as uncertainties and limitations, in a language that is simple and transparent but retains scientific quality. Programs should teach early-stage scientists to use widely accepted policy formats such as policy briefs, fact sheets, etc.

5. Policy impact: All participants need to define the policy impact, that is, the outcomes they want to achieve. Collaborators in the planning process can articulate long-term policy goals and identify the conditions they believe have to be met. All collaborators need to be aware that policy impact through the research results will continue to unfold after the fellowship has ended. Resources need to be made available towards these ongoing processes.

6. Mentoring: Organizers of science-policy programs need to install policy mentors in the academic institution easily accessible to early-stage researchers. These mentors could offer guidance in distributing time between research and policy work, offer methodological support in policy work, and facilitate outreach, dialogue and information planning. Complementary to these, advisors at the policy organization need to reserve time for guidance on structures in the policy institution. Both parties can offer support with the project design at the science-policy interface.

7. Visibility: Make the collaborations and policy outcomes visible. Showcase successful projects and use them as examples to inspire others.

8. Capacity: Sufficient organizing capacity is vital. Organizers of science-policy boundary work need to support recruitment, selection and placement of participants, keep relations to policy institutions alive, facilitate participant networking, and offer training and mentoring in boundary work and professional development.

9. Incentives: Universities should reflect on reward incentives for early-stage researchers and their supervisors. Incentives could include: 1. Establish career paths for scientists who engage in policymaking. Science-policy boundary work should become an appreciated part of scientific CVs for tenured positions for researchers responding to societal needs. Policy reports carefully reviewed in collaboration with policy partners should get the same recognition as peer-reviewed scientific publications. Selection committees for academic positions, or for grant applications, need to pay attention to science-policy qualifications. 2. Establish financial incentives for scientists engaging in knowledge transfer activities as part of grant-awarding mechanisms.

10. Long-term institutional support: Best-practice examples of regular exchange between scientists and policymakers are generally project-funded. But institutions should commit sustained financial support to this area. This is critical for the development and maintenance of exchange mechanisms and to establish branding and reputation (Gual Soler et al. 2017).

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