The Evolving Scholar vol. *3*, 2023 *doi*:10.24404/64104e5efa1dfac3f15789e7
ISSN 2667-2812

Why do we do science?

Navigating the paths of individual excellence and team science

Received 14 Mar 2023

TU Delft OPEN

S. Flipse & E. Kalmar

Faculty of Applied Sciences, Delft University of Technology, Lorentzweg 1, 2628 CJ Delft, The Netherlands

S. Flipse
Emails: S.M.Flipse@tudelft.nl
E. Kalmar
Emails: E.Kalmar-1@tudelft.nl

About This Opinion Article

In this opinion article we address an issue that has been emerging for some time now within the academic community: how do we align our personal career perspectives with ideas of democratic, open and inclusive research & innovation strategies? We address this issue and voice our concerns regarding the governance of this alignment within our lovely institution, in the hope that it provides a starting point for further deliberation amongst our scholars and students.

Research Highlights

- We are convinced that currently, our staff and students do not pay enough attention to the implications of walking the path between individual excellence and collaborative science endeavours. Making choices on how we see our academic study programs and careers, is based on different interpretations and assumptions around personal and institutional values.
- We observe a difference in perspective between scholars in research fields that are historically more discipline-oriented in nature, and fields that are more widely socially oriented in starting points for their scholarly work, but often without explicit consideration of this difference and how it influences how collaborative science plays out in practice.
- We observe a difference in how (and how intensely) collaboration is integrated in student curricula. If we want to change the educational system to be more about inclusive science, we have to start by making more explicit choices about this in our own research agendas.
- With a thought experiment we show that if collaborative science is valued as much as disciplinary science, this makes everyone's achievements within the institution less special. This means that perceptions (and associated worth) on what it means to be an academic will shift, more people will have to be promoted for their (wider array of) achievements, and disciplinary knowledge becomes less 'special.' So, broadening what is considered 'talent' also leads to a dilution of what is considered 'excellence'.

- If we are moving towards more collaborative science, discipline-oriented scientists should stop hiring future clones of themselves.
- The current (lack of) initiative by our collective management to discuss these and related issues does not do justice to the value of making explicit governance-related choices on the supposed role of the Delft University of Technology in society.

1 Getting started: perspectives on our knowledge society

We live in a knowledge society. Knowledge – in addition to mineral resources, capital and physical activity – is an increasingly important resource. It contributes to the functioning of democracies and innovation and helps countries to be globally competitive. But the academic world, which contributes significantly to knowledge production, is confronted with new challenges. Classical, single-disciplinary approaches slowly make way for multi-, inter- or transdisciplinary groups, projects and educational programmes. Is this a movement for the better?
Perspectives on this topic within the TU Delft differ. Some argue that the key to 'good science' starts from solid disciplinary knowledge; starting from anywhere else leads to sub-optimally academically grounded solutions. Nonsense, others say; starting from the perspective of societal problems embedded in complex social systems is the best way forward: Science is not there for Science; it is there for Society.
We observe the same combination of perspectives within our own institution: fundamental physics education (AS faculty) exists next to broader and more socially embedded programmes such as Complex Systems Engineering & Management (TPM faculty). Or, even within one faculty, the Master programme Architecture, Urbanism and Building Sciences offers technical tracks on architecture, as well as more broadly socially embedded tracks on management in the built environment.
Simultaneously, in research we observe fundamental and disciplinary quantum science projects, as well as technical multidisciplinary collaborations such as the E-Refinery. And even transdisciplinary collaborations that transcend all disciplinary boundaries within the Resilient Delta Convergence Initiative, where public social, technical and economics actors and humanities scholars work together to address real-world challenges. What does this development in disciplinary fields mean to an institution like the TU Delft? What impact does it have on our educational and research programmes? And, are we sufficiently equipped to accommodate this movement? We address these and other questions, starting from the perspective: what makes us 'tick' as scientists at an academic institution?

Why become a scientist?

Citing from the Vision statement of TU Delft: "One important characteristic of TU Delft is that we not only strive to be good at what we do, but also that we want to be good for something. At TU Delft, we strive to balance our pursuit of world-class academic excellence on the one hand and providing high-quality education and expert-solutions to societal problems on the other hand."(TU Delft, 2023c)
Apparently, our leaders recognise that the TU Delft has to excel academically, as a research institution, and we also have to provide education and solve societal problems. But by presenting this as on the one hand and on the other hand, the question arises if and where we can make these two hands' shake'; whether we can make them support something central, something that they both support. The current situation appears to be a non-strategically grown mix of single disciplinary research fields – r epresented a s g roups w ithin sections within faculties and some discipline-focused educational programmes, and multi- (or inter- and perhaps trans-) disciplinary research fields – represented as wide collaborative, inter-faculty, or inter-institutional research projects and broader educational programmes. But the question is if this combination of what appear to be naturally grown initiatives, can develop into a strategic choice with active governance and managerial guidance.

An **Opinion Article** on collaborative vs. individual science

Regardless of which of the two perspectives is or becomes leading, the question remains in which direction this will be moving in the near future. This movement greatly impacts how we view education, what our roles and responsibility are as researchers and what are the reasons behind our commitment to being academics in the first place. In the following sections, we will present our views on collaborative science, what this means for future education, and how future collaborative science might be institutionally supported.

2 Opening up the way we do science by asking questions

Science and innovation are tightly related. We need scientific results for technological innovations, and these technologies have – or at least should have – an effect on how we do science. At times when policymakers would like to figure out which factors could increase the innovativeness of a given region or country, we rarely hear about innovations that reform science itself. The first scientific revolution in the 17th century laid the foundations of various scientific disciplines and the principles that guide how science is performed. The basis of the publication system, for example, was founded in the 1660s, and apart from slight adaptations to digitalisation in the last decades, it has not changed much since: we still download articles in a format of a printed journal due to historical rather than rational reasons (Bartling and Friesike, 2014). Scientific publishing shaped and, at the same time, limited the way in which science is performed, by determining how ideas and results are shared within the scientific community.

Open and responsible science

With the spread of the novel European Commission plans for Open Science, more and more academics question the current ways of scientific publishing. Most of us find that results of scientific studies that were funded from governmental grants ("citizen's money") should be available for everyone without a subscription to the journal or paying for the individual article.

Open Science shouts for transparency in various aspects of scientific inquiry, not just at the level of publishing (Maier-Rabler and Huber, 2011). They argue that data should be gathered, stored and made available for other scientists to check and reuse. Other movements also point out weak points in the scientific life cycle. For example, Public Engagement in Science campaigns for including non-scientific stakeholders in distinct aspects of research: citizens in collecting scientific data via citizen science projects, or lay people's local and contextual knowledge in discussing technological risks and research policies to democratise science-related decision-making (Stilgoe et al., 2014). Responsible Research and Innovation principles were formulated to involve external stakeholders in the research process to start talks on the ethical aspects of science (Owen et al., 2020, Fraaije and Flipse, 2020).

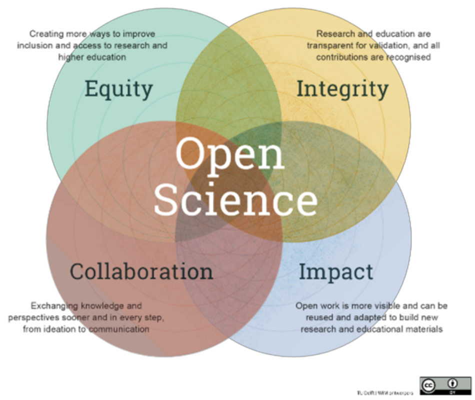

Figure 1: Open science goes beyond publishing– it is a redefinition of scientific collaboration and output (TU Delft, 2023a)

These different movements challenge the current ways of performing science. Who should be part of the data collection? Who should have a word in the way a given research is performed? Who should read scientific results? Who should decide which projects should be performed and who should grant these? How do we measure scientific excellence? If the publication system is old-fashioned and biased, as Open Science advocates say, is it reliable to judge how good scientists are, based on their publication list? NWO signed the San Francisco Declaration on Research Assessment (DORA) in 2019 and implemented its principles in the assessment procedures, taking a big step towards changing the measurement aspects (Netherlands Organisation for Scientific Research, 2019). This shows that we need to start a discussion about these issues, and figure out a potential solution also within our own institution.

Asking ourselves why we do science

We believe that asking such questions, such as "Why we do science?" can help us to see what the issues are, and what needs to be changed. The choice between science done to gather fundamental knowledge and science done to solve societal problems has consequences on how we make decisions about how we organise our research projects. The two answers might not seem that far apart, but they put you in two different paths when you need to set up a collaboration. Namely, if the focus lies on deepening scientific understanding or creating new technology, one might choose collaboration partners that have similar backgrounds but have access to different methodologies or instruments. In contrast, if someone sets solving societal problems central, then the collaboration needs to contain diverse collaborating partners to cover different values, perspectives, knowledge fields and interests. This is because complex societal problems have multiple definitions, are viewed differently from different stakeholder perspectives, and, unfortunately, cannot be solved straightforwardly. Teams that are trying to come up with a solution need to tackle the complexity through inter- or transdisciplinarity (Kalmár and Stenfert, 2020).

Change requires different systems and skills

Yet, the classical scientific life cycle and the research support systems are based on and further support fundamental knowledge creation. Classical disciplinary university education focuses on individual performance; universities and research institutions evaluate and reward researchers individually. Next to big collaboratory projects, grant providers still publish calls for excellent individuals to persuade their own dream projects (ERC, VENI, etc), and PhD candidates are hired individually. In universities and research institutions, researchers are part of their research team with several other scientists, PhD students, Bachalor/Master students and assistants, usually led by a principal investigator (PI). In these "home teams" researchers need to cooperate, but also compete with fellow PhDs and post-docs for getting recognition within and outside of their own institution.
Scientific collaborations are often formed outside of these home teams, between different faculties and universities, often with industrial partners, governmental organisations and (representatives of) users. Working in such project-based temporary teams means stepping out of the hierarchical home institution and learning or creating new social rules. Managing projects, negotiating expectations and desired outcomes, sharing knowledge, and creating new methods and theories in these kinds of multi-, inter- or transdisciplinary collaborations require specific skills not covered by classical university education. Inter- and transdisciplinary teams set up to solve societal or complex problems have specific team dynamics. At the beginning of these projects, partners bring their own purpose, knowledge, definitions of concepts and interpretations of the problem. These partners also have different ways of approaching the problem and negotiating with each other on how to move further. One of the greatest challenges of these interactions is to bring the different perspectives, problem definitions and potential ways to solve the problem close to each other (Gray, 2008).

Social learning to address grand challenges

The convergence of these differences could be seen as social learning, as this leads to shared mental models and the generation of new knowledge. Science communication, social science, and team science provide us with theories, models and methods to understand how such teams function, what methods or interventions can be used to support the desired team processes, and why other methods should be avoided when communicating with diverse stakeholders, especially in situations when the interests are conflicting (Kalmár and Stenfert, 2020).
Sustainability, energy transition, resilient cities, rising sea level, health care reforms. Projects highlighted at TU Delft's main homepage. These are all complex societal challenges which have technical perspectives, but cannot be solved without engaging versatile stakeholders, listening to their ideas, integrating their knowledge and interests. For these, we need specific scientific knowledge, but also communication, collaboration and social skills. Then why don't we teach these specific skills together with rigorous scientific methodologies and theories? In our next section, we will discuss the topic of how we (should) educate our students.

3 Education as preparation for multidisciplinary global problem solvers

Within the TU Delft we pride ourselves on offering good quality and positively evaluated academic education on BSc, MSc and post-master (PhD) level. And perhaps rightfully so. Nevertheless, a valid question remains: what are we actually preparing our current and future students for?
According to the vision statement in the current strategic plans, the "Delft University of Technology contributes to solving global challenges by educating new generations of socially responsible engineers and expanding the frontiers of the engineering sciences." (TU Delft Executive Board, 2016) We acknowledge that this requires deep content knowledge of (one or multiple) disciplinary fields, and also a wider view of the social-economic and technical ecosystem in which such deep content knowledge can be channelled in to useful (and possibly also socially responsible) contributions to solving global challenges.

T-shaped profiles for all our students?

This 'T-shaped profile' (Oregon State University, 2023) is also acknowledged within the strategic plan, through which "[...] our graduates acquire a thorough and in- depth disciplinary knowledge, while at the same time (usually in the minor and MSc programme) familiarising themselves with other disciplines and developing competences in the application of technical expertise to 'real world' complexities."

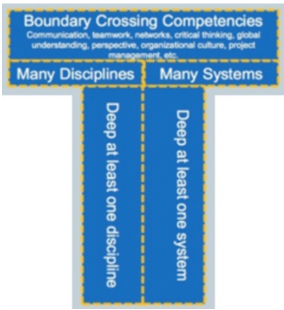

Figure 2: The T-shape profile (Oregon State University, 2023)

We can discuss to what extent this is the case, but more reliable is perhaps a short overview of student perspectives on this matter. We quote experiences from five students who are currently enrolled in the Communication Design for Innovation MSc program, which most students follow as a double degree MSc program in conjunction with another engineering program at the TU Delft:

- *I've become significantly more open to a wider spectrum of viewpoints in my work as an engineer. No longer am I only focused on the solution to a problem, but also in the process the people involved and how those people feel and interact.*

- *I have only been in the program for a month and it already recontextualises so much of my previous experiences within and outside academia. I am of the opinion that certain parts of this master program should be included in every other master program as well.*

- *Having technical skills does not always mean that you know how to put these skills to use. When I talk about the CDI programme to other students of TU Delft, the only reaction I get is that they wished they knew this programme existed.*

- *In short, the added value of the CDI programme lies not only in the addition of an important skill set but also in a way of thinking and behaving when working in the scientific field.*

- *I'd say it's by far the most complete education I've received so far because it not only taught me valuable knowledge and communicative skills, it also improved my creativity and confidence, and showed me how to use all this to initiate change in complex systems.*

By extension, these descriptions all imply that in their technical / engineering programs, such broadening modes of thinking are largely lacking. But they also imply that if you don't know that you miss these broadening mindsets and skills, you also not likely to go look for them.

Deep or wide profiles?

Still, while we think such T-shaped profile development is recommendable, the question is how deep and wide such Ts should be for students to best be able to address the global challenges that lie ahead. Since there is limited time and capacity within any curriculum, depth may come at the expense of width and vice versa.

Different perspectives seem to exist. There are those who argue that our task as educators is primarily to train content experts, and the focus in education should be to cover as much content-relevant knowledge as possible (possibly at the expense of a wider societal view). We find this 'empty vessel theory' [1] for example at the Applied Physics master which contains advanced math, general advanced physics electives and specific MSc Track related electives, an internship and a thesis project; and to widen the T, an ethics and engineering course (and possibly some room for other electives if the student so chooses).

Yet, there are others who argue that our task is to train experts who are open to the social-ethical and economic complexity of problem-solving associated with addressing global challenges. They offer programs like the MSc in Architecture, Urbanism and Building Sciences, with e.g. a track in Management of the Built environment, that contains content-related courses around economics, management and law, but also courses that cover con-

[1] In this theory, in short, students are considered empty vessels that need to be filled with content knowledge before they can functionally participate in society; in contrast to students being considerate human beings with their own normative frameworks, perfectly capable of functioning in a social system, improving on their contributory capacity to help society as their academic paths progress.

tent against a wider societal background, around redesigning complex (urban / infrastructure) projects and much room for free electives.
The question is then what the 'top of the T-shape' actually is. Does it comprise an overview of different sub-disciplines (Physics of Energy Materials, Chemistry and Physics of Solar Cells, Energy Storage in Batteries, Molecular Electronics, Nuclear Reactor Physics, and Materials Chemistry for the Nuclear Fuel Cycle, as part of an Applied Physics track) to help students develop a broader view on the discipline? Or an overview of different disciplines related to a wider global problem-solving perspective, like courses on actor and strategy models, intercultural relations and project management, ethics and impacts of global interventions and macroeconomics for policy analysis, as part of the MSc program in Engineering and Policy Analysis.

Science communication and team science: connecting the different disciplines

To solve complex societal challenges which have technical perspectives, we need to engage various stakeholders, listen to their ideas, and integrate their knowledge and interests. For these, we need specific scientific knowledge, but also communication, collaboration and social skills. If we need to master these skills, amongst other 21st-century skills, such as problem-solving, design thinking and so on, we need to incorporate these into the education programmes.
Science communication is often counted as a skill to communicate scientific results to the wider public. We think differently. We believe that Science Communication is (or should be) a team project, an interdisciplinary collaboration of different stakeholders, such as communication experts, researchers, policymakers, librarians, artists, curators of musea, and representatives of diverse citizen groups. People who are communicating with these stakeholders need to master social scientific research methods to gain information on their target groups (Kalmár and Stenfert, 2020). What is important for them? How do they make decisions? Why are they against or for some improvements? Then they also need methodological knowledge on how to perform good public engagement, citizen science or participatory design projects. Science communication is therefore not just a skill on how to talk to a wider public. Although there are science communication tracks or specifications at several universities, science communication should be incorporated into every academic BSc and MSc programmes.
Teamwork is already part of several BSc and MSc programmes. But do the students who are asked to perform teamwork learn how to do that? Are they coached properly? Or do we just let them do it, expecting that they learn it by doing? How do we help them when they consider difficulties if the lecturers or teaching assistants do not have any background in team science?
Project- and challenge-based education is trending over technical universities. TU Eindhoven won the Dutch Higher Education Awards for this type of education (TU Eindhoven, 2023). In project-based courses or programmes, student teams work on a project for a client, defining their own learning path, and creating a prototype as a solution for the actual problem. It provides the possibility to learn and practice the skills needed for inter- and transdisciplinary collaborations (Guo et al., 2020). Setting up such programmes or courses requires a lot of effort from the education designers, and giving such education demands another perspective of teaching: coaching teams. It is a special expertise with special knowledge in the science of team science. This new scientific discipline collects knowledge basis on team dynamics, important factors that determine the effectiveness of teams. We do not have to reinvent the wheel, just apply the knowledge collected on teams.

Reinforcing loops

Some might argue that students know 'what they're getting themselves into' when they apply for a program; that physics students are just possibly more inherently interested in the content, while students who study at the faculty of Technology, Policy and Management are just more interested in the wider societal context. And that might be fine. But, does that mean that students with a more technology-focused engineering degree are better or worse possible contributors to later global problem-solving? The easy answer is that perhaps we need both. But is that a good reason to let curricula remain the way they are?
Yet, before we can answer that question, there is another dichotomy that is worthwhile to address: the role of individual excellence vs group collaboration skills. We seem to observe that with a content focus comes a focus on individual excellence: those who do very well in the technological content-knowledge courses (which are almost without exception graded through an individual exam) score high individual grades and can earn a 'cum laude' on their technical diplomas, to pave the road for a technical PhD that is also valued individually, to continue to a post-doc for another individual technical research project, to continue to a content-focused Tenure Track, etc. On

the other side, there are programs in which there is more attention to group work, more eye for wider disciplinary knowledge, and more general knowledge. But this lack of individual focus makes it more difficult to 'stand out' or 'shine' as an individual in the individual-focused evaluation systems that a (technical) university offers.
And there are also other consequences of this system of rewarding individual excellence. Suppose those who originate from a program that focusses on individual excellence continue to develop such programs. In that case, this leads to a self-fulfilling prophecy: what has worked for them earlier will also work for future students and that's that. The same applies to programs that focus on collectivism. But the consequence is that people trained in individuality-focused programs will be more likely to hire new colleagues with a similar profile and less likely to hire colleagues with a wider perspective (and similar for colleagues in the more social and group thinking fields). If anything, this only widens the gap between the two perspectives.

Shooting stars vs. the dinosaurs

In other words, our own staff population with its own normative (implicit and explicit) values, lies at the origin of the current situation. And then the real question becomes how change can be realised within an organisation that builds on academic freedom and (frequently) quite solitarily operating faculties, departments and sections. A cynic might argue that those who value collaborative perspectives and are not quite keen on individual excellence leave the academy as soon as they get their degrees and start their careers elsewhere. Does this mean that we cultivate our own population of e.g. PhD candidates, post-docs and tenure trackers as individualists, or is it the case that more collaborative and multidisciplinary 'shooting stars' are in fact, killing the old, individualistic and domain-centred dinosaurs?
The possibly required change in our programs is also indicated by the fact that most of our hired PhD candidates (and other staff for that matter) are explicitly not alumni of our own programs. One can wonder, what makes other candidates more suitable for positions within our faculties? While we certainly do not opt for the selection or preference of just our own students for the sake of 'it being our own students', it is still interesting to explore what (implicit and explicit) reasons might be at play with regard to the preference of other students, other than selection criteria determined by grant organizations (for example for the Marie Curie PhD positions). What skills are 'we' looking for that we cannot seem to find in our own candidates? And, most importantly, how do we change our own programs to align better with these presumably preferred profiles?

Figure 3: Shooting stars vs dinosaurs (source: https://www.justpo.st)

4 Changing the games we play

The continuous dual imperative between working with people and excelling individually can be considered both positively and critically. Depending on personal ideas and values, some of us value the collaborative character of our work, get energy from working with others, and teach students to open themselves up to other disciplines, ideas, world views and value systems. Others focus mainly on gaining a deeper understanding of their own topics and interests and value other scholars' input primarily because it helps them to expand on their own interests.

From a democratic, societal perspective, it might be easy to advocate for collaborative and socially oriented academics and to 'judge' the more self-focused or self-centred academics. But the individual focus leads to 'successful' scientists for a number of reasons. Two primary reasons we make explicit here. First, the grant system partially still rewards personal excellence through individual rewards that do not require any involvement of collaborating (internal or external) partners outside of their own discipline. Second, PhD candidates that have published (individual) papers to demonstrate their academic competence in a specific subject area are more likely to get a job as a post-doc than PhD candidates with a broader profile who also focused on teaching and (social or economic) valorisation; in fact, some groups do not even stimulate PhD candidates to also gain teaching experience and to be involved in 'other activities' than just the science, also within our own institution[2].

A thought experiment: focus only on individual excellence?

As a first thought experiment, we wonder what would happen if we continued organising science in the 'classical' discipline-oriented sense. Scientists move forward to develop their own disciplinary knowledge and only reach out to others because it leads to better or more insights into their own fields of knowledge, while maintaining their disciplinary boundaries and reaching out as little as possible. This leads to disciplinary fields that might be taken very seriously within their own fields, but a system emerges where outreach to other fields that might benefit from obtained insights is not per se granted. Others become more and more estranged from these growing sub-sub-(sub)-disciplines; funding systems, who keep having a responsibility to fund relevant science, will find it harder and harder to distinguish who to fund and based on which criteria. This has two consequences. First, we create individual knowledge islands with distributed knowledge and knowledge systems. In such systems, everyone fends for themselves, and team efforts are merely a necessary evil to obtain more individual results. And second, rather than scientists selecting the fields where funding is possible, the funders have to make strict choices as to where the money goes. If anything, the prospect is not that this leads to an increased capacity of shared problem-solving and collaboratively addressing grand societal challenges.

The academic version of the prisoners' dilemma

The choice between individualistic excellence and team effort greatly resembles the situation depicted in the prisoners' dilemma. The classical version of this game theory-based decision analysis is about two prisoners, who cannot communicate with each other, but their fates depend on their collective decisions. The parameters of this dilemma are set up in such a way that cooperation results in the least amount of punishment (shortest prison sentence), but if one betrays the other (confesses against the other), then the betrayer gets zero years, while the other receives a significantly larger sentence. If both confess, their sentence will be between the two extremes. This dilemma is often cited to illustrate how trust and individual interests can define whether we do what is best for everyone or choose for the better than the worst scenario (Méró, 1998).

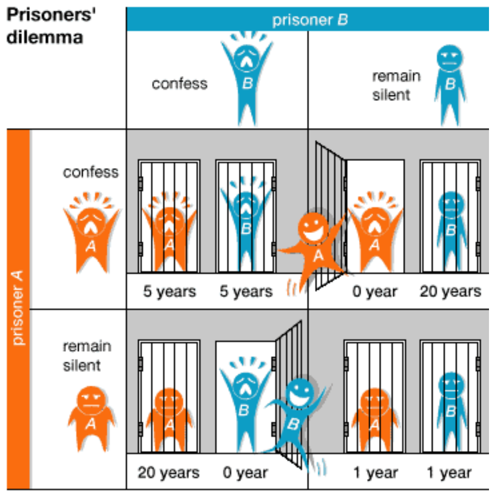

Figure 4: The prisoners' dilemma (source: http://www.prisoners-dilemma.com)

The prisoners' dilemma would look like the following in the academic context. Two researchers are considering applying for a grant. They can apply for a joint grant or an individual one, but not for both. The pre-application deadline for both grants is on the same day. Both scientists can register for only one call: the joint one or the collective one. If they apply for the joint grant, they can get more money for an impactful multi- or interdisciplinary research project, compared to the individual project. If they do not trust that the other applicant is good enough to be judged positively by the grant providers, and therefore they are not sure they will get the grant, they risk their own scientific career too. In that case, it is worth going for the individual grant, potentially leaving the other scientist without a grant application.

Game theory, especially the prisoners' dilemma, was used in countless different contexts. One study (Rong et al., 2019) focusing on networks showed that people who chose cooperation in a situation similar to the prisoners' dilemma were more likely to become leaders than those who behaved individually. They attracted more followers who copied their collaborative behaviour, which shows the possibility of changing the current system if more and more people apply collaborative behaviour. It is essential to highlight that the points gained in this game, namely the benefits and the punishments of each strategy, which

[2]More worrisome, we have even heard voices of groups that even consider participating in the TU Delft's graduate school courses as a waste of time or even a 'necessary evil'.

shape how the players decide, are defined by institutions that hire, promote and finance researchers. Therefore, it is essential for all of us to start a discussion on what is important and which strategies are to reward at institutional, national and international levels.

Recognition and rewards

By and large, our institution, TU Delft acknowledges that a broader 'reward and recognition' system is warranted and has developed a 'recognition & rewards perspective 2021-2024'. In that perspective, various levers of change are identified, including role modelling, developing talent and skills, fostering understanding and conviction and reinforcement with formal mechanisms. These plans are currently evolving and under continuous development; e.g. our Result & Development cycle has been changed (the results and experiences of this new cycle are still pending), there will be a novel approach to the 'tenure track' and new trainings and leadership development programs for staff have been launched. However, some things remain unclear in the descriptions on the R&R communications (TU Delft, 2023b).
For example, it is unclear who gets to be a 'role model'. As we saw, people who choose cooperation in a prisoners' dilemma are more followed, and their cooperative behaviour is taken up by others, which is great news if we want to attain systemic change. But does this mean that an excellent "solo" researcher cannot be a role model anymore? Do we want TED talks allowing only teams to present?
Second, it is not clear which skills should be trained and how. It starts with acknowledging that some skills have not been trained and are underdeveloped. But how does one train someone to become more 'open' to teamwork and collaboration? We should avoid the mindset or vision on how to do science to be reduced as a mere 'trick' to become more rewarded or recognised.
Third, fostering understanding and conviction includes, according to the perspective, 'better onboarding of new employees and managers', where the term 'better' includes an implicit value judgement that implies that something is currently 'worse' that needs to be improved. Not everyone might agree with that assessment, in particular when those who are leading the institution are those who have built their career on individual excellence through personal grants.
Fourth, formal mechanisms can even further stimulate 'trickification' (second point above) of the collaborative mindset and cannot happen in mere isolation within one institution.

Another thought experiment: everyone's special

Of course, managers will acknowledge that a new rewards & recognition system is needed, especially to show diversity in career paths; so not just individual excellence, but also teamwork. But broadening what is considered 'talent' also leads to a dilution of what is considered 'excellence'. Namely, if more than one thing is considered excellent, how 'excellent' are people then. For example, consider the following thought experiment:
Let's substitute scientific excellence with chess grandmastery. An ambition of good chess players may to become excellent players, winning matches, being considered grandmasters at some point in time. The status of grandmaster may be the result of years and years of practice, but may also be granted to really talented young players with extraordinary insights. Chess players aspire to become grandmasters and play in the big leagues, for the big money. And now, all the sudden, we change the game of chess to a team game: the team leader may only command one type of chess piece and may be rewarded for excellent handeling of that particular piece only. The question is: who will still become grandmaster? Or will we have separate masters, e.g. for the team captain, the team coach? Will we have, similar to soccer, 'transfers' of players that excellently handle the Knights or the Rooks, from one university to another? Is it even fair to reward a 'player of the year' if in fact any player relies on the other players as well? It might be that this leads to many more types of grandmasters, diminishing the value of the grandmaster status; or, if the status of grandmaster remains as exclusive as it is, if more styles of playing may be rewarded, this always comes at the expense of the number of 'classical' or 'normal' grandmasters. It also fundamentally changes the reasons why people will move into chess (or science).

Figure 5: Messi and Ronaldo playing chess (source: Louis Vuitton)

So the question is what the Delft University wants. Either reward (and promote) more scholars in the system towards professorship or reduce the chances for everyone who wishes to excel personally in their academic careers. The first one is expensive on the long term and may lead to the 'professor status' being less valuable. The second means admitting that individual excellence isn't as valuable anymore as it used to be, which requires a big culture change with may be difficult to establish in the 'individual winner' system.

Four starting points for change

So, where can we start with this challenge to change the culture of science? It definitely requires a systemic change that needs adjustments in policies, everyday practices, social norms and especially mindsets at the individual, team, organisation and policy-making levels.
We argue that there are four starting points, just slightly different than the ones in the rewards and recognition perspective (figure 6), which we identified through our earlier research in Communication Design for Innovation.
On the level of the individual researcher, we distinguish elements that people can learn (including ways of interacting, different ways of learning and profiling yourself) and factors that are more socially determined and take a certain mindset (motivation to collaborate, learning attitudes and willingness). On the level of the system, we similarly distinguish elements that can simply be organised and offered by the university (including data management methods and tools and other information exchange systems) and more difficult-to-influence elements (including the culture and social system of teamwork and observed team mentalities).
Courses and information platforms might be easy to implement and are a good starting point, but we also know from our research that the affective side of teamwork is much harder to change. E.g., we observe systems where the focus on individuality does not play a central role (e.g. in the social help and services domain), where teamwork is the norm rather than the exception. The only logical conclusion is that such domains are filled with people with different attitudes, and the question is why others have such different attitudes towards social (learning) behaviour. This essentially boils down to another 'nature vs. nurture' debate: do we have a system like the one we have, because we hire people with a mindset that is not system-oriented but individual-oriented (and therefore, we should hire different people based on different selection criteria), or because we trained our students and staff to behave the way they do (and should we change the training accordingly).

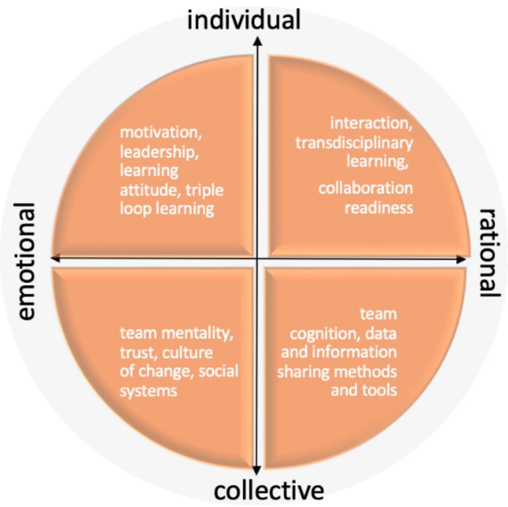

Figure 6: Four quadrants in collaboration systems

We propose various system-level changes. First, we advocate adopting a system aligned with what the Dutch Royal Academy for the Sciences (KNAW) proposes. They launched (31 October 2022) a report[3] that was developed by scholars from the Vrije Universiteit in Amsterdam, that suggests four-step advice: connecting science communication with open science policies; making communication a serious part of the academic tasks; integrating communication in all phases of scientific projects; taking communication seriously as a discipline with associated expertise. This entails adding communication, collaboration and system thinking to the core of the academic work that takes place at our university, not as an add-on but as an added disciplinary field in all research projects, on an equal level with other academic competencies.

Second, we opt for breaking with the selection criteria that reinforces the current system, which has governed the academic system to an important extent so far. In light of various projects, we have spoken to many senior academics who are looking for people with similar traits as they themselves have or had, 'growing up' in the academic field. This does not explicitly warrant that people are hired with a collaborative mindset as a starting point rather than a content focus to begin with.
Third, we opt for starting science not merely for the sake of science and to develop sciences into disciplinary fields; but rather for the sake of social

[3]https://vu.nl/en/news/2022/science-communication-integral-part-of-academic-duties

knowledge collection with transdisciplinary perspectives and with a thorough understanding of the social system - the world - around us.
And fourth, teaching future students starting from this perspective also.

Room for both specialists and generalists

We would not like to be mistaken for advocates against specialised knowledge. On the contrary, our idea is that specialised knowledge generation also benefits from more collaborative research activities and widening scopes. Yet, finding a novel modus of doing science that includes Open and Responsible scientific principles like the active inclusion of stakeholders, other disciplinary experts, other universities, citizen science, data sharing, and other approaches are difficult to realise. Our idea is that creating a new system of knowledge production starts with a wider than just single-disciplinary education. That can only be realised if we ourselves, as members of the academy, open up to principles of open and responsible science. Then deep disciplinary knowledge and broad societal perspectives can really meet, but only when more collaborative research endeavours are embraced as the norm and not considered an instrumental means or a necessary evil. This also requires that we train our students as both specialists with a wider, open view and as generalists with the capacity to bind content together for the greater good.

5 Contributor Statement

Eva Kalmar and Steven Flipse wrote this paper together. They thank the discussions with Thijs Elzer, Floor Driessen and Ingrid Fos that led to interesting ideas and shaped some aspects of the article.

References

Bartling, S., & Friesike, S. (2014). *Opening science: The evolving guide on how the internet is changing research, collaboration and scholarly publishing*. Springer Nature.

Fraaije, A., & Flipse, S. M. (2020). Synthesizing an implementation framework for responsible research and innovation. *Journal of Responsible Innovation*, *7*(1), 113–137.

Gray, B. (2008). Enhancing transdisciplinary research through collaborative leadership. *American journal of preventive medicine*, *35*(2), S124–S132.

Guo, P., Saab, N., Post, L. S., & Admiraal, W. (2020). A review of project-based learning in higher education: Student outcomes and measures. *International journal of educational research*, *102*, 101586.

Kalmár, É., & Stenfert, H. (2020). Science communication as a design challenge in transdisciplinary collaborations. *Journal of Science Communication*, *19*(4), C01.

Maier-Rabler, U., & Huber, S. (2011). “open”: The changing relation between citizens, public administration, and political authority. *JeDEM-eJournal of eDemocracy and open Government*, *3*(2), 182–191.

Méró, L. (1998). *Moral calculations: Game theory, logic, and human frailty*. Springer Science & Business Media.

Netherlands Organisation for Scientific Research. (2019). Knaw, nwo and zonmw to sign dora declaration [Accessed: 2023-03-03].

Oregon State University. (2023). Oregon state university [Accessed: 2023-03-03].

Owen, R., Macnaghten, P., & Stilgoe, J. (2020). Responsible research and innovation: From science in society to science for society, with society. In *Emerging technologies: Ethics, law and governance* (pp. 117–126). Routledge.

Rong, Z., Wu, Z.-X., Li, X., Holme, P., & Chen, G. (2019). Heterogeneous cooperative leadership structure emerging from random regular graphs. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, *29*(10), 103103.

Stilgoe, J., Lock, S. J., & Wilsdon, J. (2014). Why should we promote public engagement with science? *Public understanding of science*, *23*(1), 4–15.

TU Delft. (2023a). Open science at tu delft [Accessed: 2023-03-03].

TU Delft. (2023b). Recognize appreciate [Accessed: 2023-03-03].

TU Delft. (2023c). Vision statement tu delft [Accessed: 2023-03-03].

TU Delft Executive Board. (2016). *Tu delft strategic framework 2018-2024* [Accessed: 2023-03-03].

TU Eindhoven. (2023). Challenge based learning [Accessed: 2023-03-03].