GLUON

Making knowledge
integration work

Introducing a new role to the knowledge ecosystem

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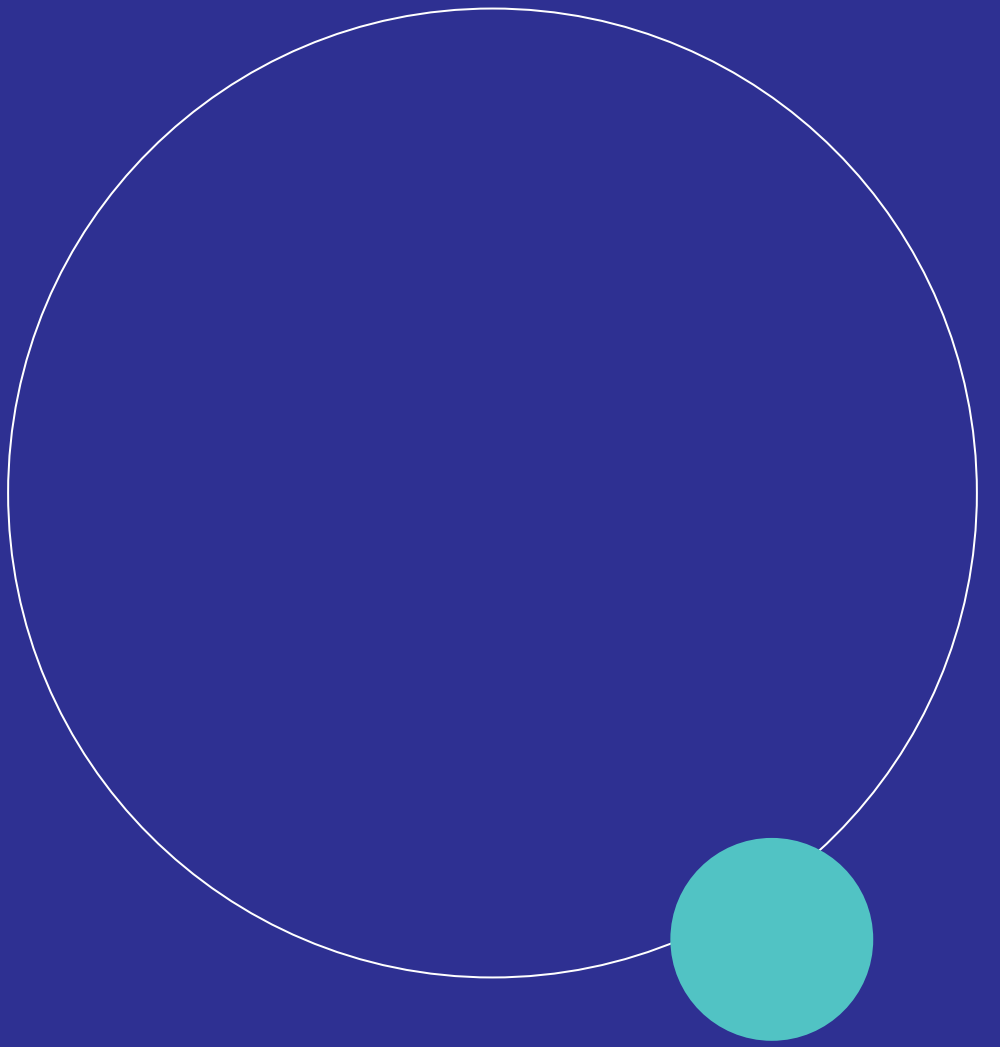
Resilient Delta initiative

Volume 1

A short series with reflections, anecdotes and insights on the Gluon approach



Gluon - Making knowledge integration work
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Volume 1

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Contents

6 **‘Breaking new ground’**
Foreword by Hans de Voogd and Arjan van Timmeren

10 **‘Nature and origins of the Gluon’**
Preface by Nikki Brand

18 **‘What it is and how it works’**
The Gluon by Nikki Brand, Johnathan Subendran, Chuma Mbambo-Lado, and Anne Bruggen

24 **‘A deep dive into knowledge integration’**
A conversation with Sabine Hoffmann

30 **‘Gluons on the Gluon’**
Reflections from Johnathan Subendran, Chuma Mbambo-Lado, and Anne Bruggen

38 **‘Frequently Asked Questions’**
A public service announcement from the Gluon team

44 **About the contributors**

52 **Colophon**

Foreword

Breaking new ground

Hans de Voogd[1] &
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1. Strategic Director of Resilient Delta initiative

2. Scientific Director of Resilient Delta initiative (2020-2024)

The first booklet in the Gluon series marks a significant step forward in our quest to enhance knowledge integration and transdisciplinary collaborations. This series embodies the dedication and innovative spirit of the Resilient Delta Methodology team and our knowledge integrators, whom we proudly call Gluon researchers or "Gluons," committed to bridging the gap between academia and practice. It is with great excitement that we present the impactful work that has developed within the Resilient Delta initiative over the years.

Operating under the Convergence Alliance—a collaborative effort between Erasmus University, TU Delft, and Erasmus MC—the Resilient Delta initiative aims to tackle complex societal challenges through interdisciplinary and transdisciplinary research and innovation. Gluon researchers play a pivotal role within this ambitious framework, serving as more than just a metaphorical connector. The Gluon approach is a strategic framework designed to integrate knowledge between academic and societal partners, enabling scientists, communities, sociologists, engineers, and other professionals to work together towards shared goals, driving methodological advancements and fostering a holistic understanding of resilience.

The mission of Gluon work is to bridge the gap between engineering expertise and social sciences, which will prove crucial for addressing the multifaceted societal challenges of the present and the future. The flexibility of the project-based Gluon role allows Gluons to evolve and adapt to the dynamic needs of the Resilient Delta initiative. Over the past two years, we have witnessed the Gluon grow from a nascent concept to a robust framework, supporting transdisciplinary collaboration and challenging traditional academic roles.

The Gluon approach has significantly contributed to the ambitions of the Resilient Delta initiative and the broader Convergence Alliance. By repositioning methodology as a crosscutting element intersecting with various thematic areas, the concept has demonstrated its capacity to address complexity in areas where human systems interact with broader systemic responses to change.

This innovative approach emphasises the necessity of integrating fundamental and applied sciences, breaking down the silos that have historically separated these domains.

Reflecting on our journey, it is apparent that the evolution of the Gluon has not been without its challenges. Integrating this role into traditional university structures and gaining acceptance from established stakeholders has required persistence and adaptability. After these trials and tribulations, the successes we have witnessed, as we will share in this series, are incontrovertible evidence for the transformative potential of the Gluon.

Looking to the future, we envision the Gluon evolving into a diverse profile that continues to bridge the gap between fundamental and applied sciences, potentially becoming a standard requirement in research proposals and funding criteria. The journey ahead is filled with opportunities and challenges, but our commitment to continuous improvement and adaptation will be key to our success.

We are incredibly excited to share the groundbreaking work of the Gluon researchers with you. This series will provide insights into the lessons, projects, and methodologies as experienced and developed by our Gluons, showcasing the impact of their work on addressing complex societal challenges. We hope you find the Gluon series as inspiring and as thought-provoking as we do.

Preface

Nature and origins of the gluon researcher

Nikki Brand[1]

1. Academic lead Methodology Resilient Delta initiative

2. https://convergence.nl

3. https://www.tudelft.nl/infrastructures

4. Conscious knowledge integration is an intentional process that sees individuals or groups actively seek to combine insights or knowledge from multiple sources. This type of integration involves a deliberate effort to recognise connections, fill gaps, and synthesise information to achieve a specific goal. It requires awareness of different knowledge domains and a purposeful approach to merging them. We anticipate that a lot of integration expertise exists, for example in engineering and design practice, but it is often not recognised as such.

5. Pfirman & Martin 2016, 'Facilitating'

6. The 'integration deficit' refers to the lack of integrative capacity found in ITD efforts when the coordination load, social transaction costs and cognitive workload required for facilitation are underestimated and underserved. We assume that the integration deficit also has a certain size, depending on the extent of undercapacity, but as yet do not know how to measure it.

7. Lyall 2019 'University careers'

8. Hoffmann et al. 2017 'Methods and procedures', Hoffmann et al. 2022, 'Integrate the Integrators!'

9. Bammer et al. 2020, 'Expertise in research integration'

This booklet, The Gluon, outlines the origins and nature of the Gluon researcher, a dedicated 'integration expert' who leads the process of interdisciplinary and/or transdisciplinary knowledge co-creation. Naturally, this integrative form of leadership takes place within a collective, which for the Gluon researcher consists of a group of people representing a wide variety of knowledge forms. The origins of the Gluon researcher lie in the creation of the Convergence Alliance by Erasmus University, Erasmus Medical Center, and Delft University of Technology in 2020[2], and the experience gained as part of the Delft Deltas, Infrastructures and Mobility Initiative (DIMI)[3] within TU Delft before that.

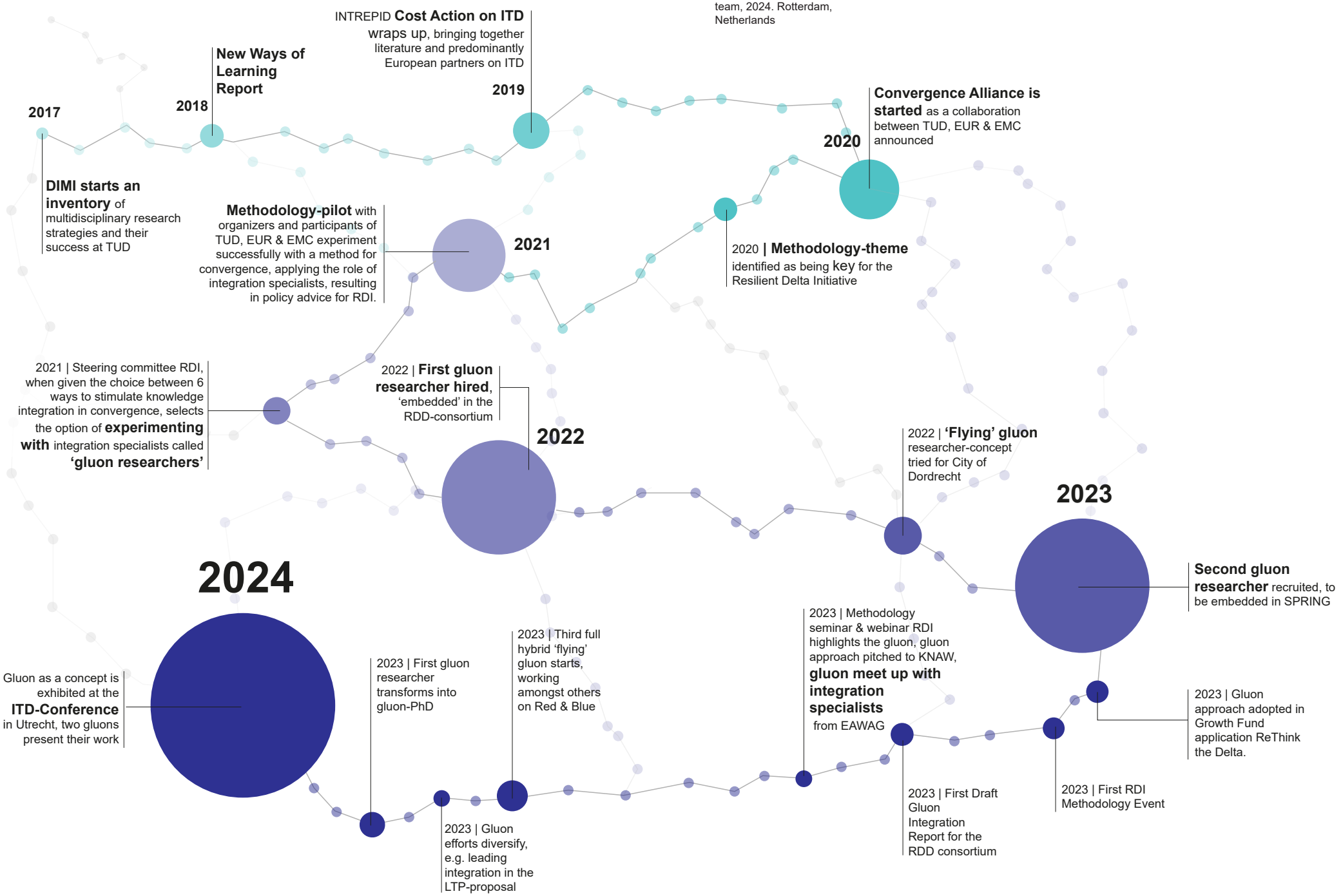
While analysing the DIMI project portfolio (DIMI subsidises collaboration between several design and engineering disciplines and their societal partners), I observed that the difficulty of interdisciplinarity and transdisciplinarity ('ITD') tends to be severely underestimated.[4] In particular, the coordination load, the social transaction costs and the cognitive skills required for such complicated, groundbreaking work are often underestimated.[5]

This results in an 'integration deficit'[6], leaving the different forms of knowledge in relative isolation and blocking ITD from fulfilling its widely promoted promise: a proper, comprehensive understanding of complex societal challenges and, therefore, a contribution to tackling these in an effective manner. It also seems likely that, due to the competitive and highly specialist culture at universities, people with integration skills often leave academia.

Knowing this, it was naive to assume that a goal as ambitious as that of Convergence - the deep integration of radically different forms of knowledge in a bid to understand and 'solve' complex societal challenges - would succeed without radically improving the conditions for ITD. Inspired by the work of Lyall[7], Hoffmann and Pohl[8], Bammer[9] and the many people organised in the INTREPID Cost Action[10], I decided to apply the concept of the so-called integration expert to the Convergence problem domain of delta resilience.

The name 'Gluon researcher' is derived from the academic discipline of Particle Physics, because of the

Fig. 1. Gluon timeline. Illustration by Gluon team, 2024. Rotterdam, Netherlands



close resemblance between this new academic profile and the Gluon particle. Like the particle, a Gluon researcher counterbalances the natural process of fragmentation that occurs when subatomic particles that collectively form a nucleus are not continuously connected. In the context of collective knowledge creation, this is also the key purpose of the Gluon researcher. They are therefore a complementary but necessary addition to a larger system: the knowledge ecosystem around delta resilience.

This book explains the design and purpose of the gluon researcher, its origins and the experience of the gluon researchers to an outside audience for the first time. This is followed by a reflection by Sabine Hoffmann, a prominent academic mind on integration experts and expertise, and a list of common misconceptions about the Gluon. The booklet is meant to be the first of a triptych that outlines how Gluons work in their consortia and the implications for ITD, as well as exploring various other forms of integration expertise.

Ultimately, this booklet also calls on other integration experts to reveal themselves and share their expertise. Integration expertise is not new but is likely hidden in various places. It is in the best interest of the world that we lean on each other for correction and validation, so that we can accelerate our collective learning.

10. https://urbantransitionshub.org/2019/10/14/intrepid-knowledge-interdisciplinary-transdisciplinary-research-and-collaboration/

Fig. 2. *The Gluon team with Nikki Brand (left), Anne Bruggen, Chuma Mbambo-Lado, Johnathan Subendran.* Photo by Cat Stoop, 2023. Rotterdam, Netherlands

The Gluon

What it is and how it works

Nikki Brand[1]
Johnathan Subendran[2]
Chuma Mbambo-Lado[2]
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11. Academic lead Methodology Resilient Delta initiative

12. Gluon team Resilient Delta initiative

13. Examples of collective integrated products are deliverables, such as reports or animations, that bring together knowledge from multiple disciplines into a cohesive output. Gluon researchers create integrated products by identifying and aligning points of convergence and divergence, facilitating holistic problem-solving of complex challenges across the consortium.

The Gluon researcher was born at the intersection of design-thinking, as studied in the Architecture and Civil Engineering faculty of TU Delft, and the emerging scientific field of 'ITD' (interdisciplinarity and transdisciplinarity). In explaining what the Gluon is, we need to distinguish the role from the approach.

Within the Resilient Delta initiative, Gluon researchers have three tasks:

- Design and implementation of integrative procedures, based on academic literature and experience (such as co-creation, facilitation and all forms of designerly practice). This division of labour reduces the workload of specialists and acknowledges the complementary contribution made by integration expertise.

- Authoring a collective, integrated product[13] written in a relatively jargon-free language. This integrated product diversifies academic output and can be co-authored by participants who feel comfortable with the content. Validation of this product relies on serial review by participants, rather than double or blind peer review, as is currently standard practice.

- The academic study of the methods they design and implement. This is the most traditional task from an academic perspective: Gluon researchers can publish their findings on the effectiveness of methods in their context in peer-reviewed literature on ITD.

Gluon researchers simultaneously learn about how to co-create knowledge in different settings and building a toolbox of ITD methods, while also extracting generalist observations about the problem domain revealed by the 'specialist input' of participants in the collective. The Gluon researcher role therefore consists of both 'doing integration' and 'studying integration'.

Although the Gluon approach is applied to complex problems, it is similar to many varieties of engineering design that are taught, applied, and studied at TU Delft. It concerns working from a rough to a fine product in a series

of steps emphasising iteration. In other words, it involves foreseeing and accepting a degree of failure during the process as a means to arrive at the most ideal outcome. The Gluon approach could also be compared to the 'integrative jump' made during a standard design process to distil an inventory of in-scope issues into a first product proposal. This is the step at which Gluon researchers transform from listeners (reacting to others) and interpreters into leaders who propose shared content to a group.

Although the similarities and differences in integrative practice between forms of engineering and design (in particular system engineering and integrated design) remain to be studied, the Gluon approach appears to differ in two decisive ways:

- First, the Gluon approach is mainly applied to complex or 'wicked' problems where a large variety of different forms of expertise are in play. This can include academic knowledge that has historically developed in distinct ways, such as Science, Technology, Engineering, Math and Medicine (STEMM) and Social Sciences, Humanities and Arts (SSHA), and experiential knowledge such as professional or personal expertise that is relevant to the topic or 'problem domain'.

- Second, a key difference is the pursuit of shared hypotheses across the sciences, by identifying research interests, collaboration points and preparing a research agenda, rather than an optimal design. This can be done in academic settings, in practice-based settings, or a combination of both. At the date of publication, we have no experience with applying the approach with other kinds of knowledge holders, such as citizens.

In the absence of accurate differentiators between forms of knowledge, we currently assume that the differences, or 'epistemological distance' between STEMM and SSHA fields, on one hand, and between academia and practice, on the other hand, will be the most pronounced.[14] Greater epistemological distance is expected to increase the chance that potential misunderstandings and mismatches will emerge in the process of knowledge integration. Knowledge integration in this context will come with a substantial workload, the possible reward - a collective, multi-faceted understanding of a complex problem, with an outlook on solution directions – is likely great.

The relatively large inclusion of the social sciences and humanities affects the gluon approach in two ways.[15] First, SSHA researchers tend to emphasise understanding problems, which counterbalances the STEM tendency to look for and implement solutions. Identifying both problem and solution bias is therefore a hallmark of the Gluon approach. Second, there are many theories and methods in the Social Sciences that can be harnessed to increase our understanding of and help design the co-creation process, such as the literature on boundary spanning.

It is important to point out that integration expertise is not new, and that it likely exists in established roles in fields such as urban design and urban planning, but also that many scientific specialists develop integrative skills as an add-on to their core expertise. The difference between these researchers and Gluon researchers, however, is that integration expertise *is* the core expertise of the latter. Whatever they learn about the 'problem domain' is an add-on to their integration know-how, rather than the other way around.

Although the ITD perspective Gluon researchers bring to problem domains can be considered a by-product of their specialization, this perspective is likely the main innovation the Gluon approach has to add to the overall knowledge ecosystem. Nonetheless, we find it is often misunderstood. Gluon researchers are not facilitators that base their practice on academic study: they make a distinct intellectual contribution to the problem domains they work on with their collectives.

Gluon researchers spend the majority of their time collecting, analysing and testing the input of others, while experts, who in academia often build their reputation on 'scientific rigour' (continuous and systematic testing of empirical evidence) spend most of their time going deep rather than wide. In the Gluon approach, validation by 'non-peers' in the collective provides the quality control needed to

14. 'Epistemological distance' refers to the gap or difference between two or more ways of knowing, understanding, or approaching knowledge

15. In that sense, the Gluon approach bears a certain resemblance to Socio-Technical Integration Research (STIR), a qualitative research method that has been used by SSHA researchers to interface with the work of natural scientists, engineers, and other technical experts. For a recent review of STIR, see Smolka et al. (2022), 'Traveling through the past and into the future of socio-technical integration research', https://easst.net/easst-review/41-2/traveling-through-the-past-and-into-the-future-of-socio-technical-integration-research-stir-midpoint-report-on-the-2022-stir-seminar-series/.

gain a rough, exploratory understanding of wicked problems and solution directions, without the reputational risk that specialists would normally encounter when roaming too far from their core expertise.

Ultimately, the role of the Gluon researcher can be seen as an ambitious attempt to harmonise different university goals (scientific research and societal impact)[16], and bridge the gap between so-called 'mode 1' (curiosity-driven) and 'mode 2' (challenge-driven) research.[17] While mode 1 research is often associated with specialisation and the need to go deep on a detailed issue, mode 2 is more responsive to complex societal challenges and calls on researchers to allow themselves to be thrown off track, hampering specialisation.

Despite heaping praise on societal impact and dedicating academic policy to its pursuit, many universities struggle to reward researchers that do not specialise on a particular problem domain. From our perspective, this persistent challenge, known as 'the paradox of interdisciplinarity'[18], has systematically hindered the progress of ITD ways of working. Gluon researchers attempt to simultaneously serve both academic missions:(i) specialisation in integration expertise and (ii) uniting diverse forms of expertise on complex societal challenges. Moreover, the Gluon approach offers universities a way to acknowledge and reward researchers that primarily serve societal impact.

16. Goddard et al. 2016, 'The civic university'

17. Gibbons et al. 1994, 'The new production of knowledge'

18. Woelert & Millar 2013, 'The paradox of interdisciplinarity'

Established research approach (left) vs the Gluon approach (right)

Do note that there is likely a variety of established research practices.

Mainstream	Experimental
Current academic roles use established methodologies and solutions based on prior research.	Gluon roles operate with no predefined solutions for the challenges they encounter.
Core expertise	**Add-on expertise**
Integration expertise is often developed as an add-on to core expertise on a relatively small part of the problem domain.	Integration expertise is the core expertise, observations on the problem domain are a by-product of this.
Certain	**Uncertain**
Traditional academic roles often involve building upon existing knowledge or frameworks.	Gluon researchers operate in areas with less established benchmarks or prior work to refer to.
Standards	**Fit-for-purpose**
Traditional academic roles have a standard practice for methods and collaboration.	Gluon researchers develop tailor-made methods and frameworks based on the specific needs of the consortium/project; they embrace methodological pluralism.
Specific	**Boundary-spanning**
Engaging in specific fields of study to address complex challenges.	Integrating knowledge from multiple disciplines to address complex challenges.
Recognised	**Unnoticed/Unknown**
Traditional academic roles are well-established and recognized within their respective fields.	Boundary-spanning work may not be widely understood and acknowledged.
Accurate	**Loose**
Traditional academic rules work with high degrees of accuracy and rigour in research. This allows for a systematic deepening of knowledge by testing via empirical data.	Gluon researchers systematically yet loosely couple ideas and perspectives to accelerate knowledge production. Their work emphasises speed, width and combination of concepts over depth.
Slow	**Fast**
Traditional academic research requires lengthy review processes and substantial protocols for legitimising research.	Gluons work accelerates collective learning through non-peer validation and can, therefore, respond to challenges more rapidly.

Fig. 3. *Key differences between the established approach(es) and the Gluon approach.* Illustration by Gluon team, 2024. Rotterdam, Netherlands.

Interview

A deep dive into knowledge integration

Dr. Sabine Hoffman and the Gluon team in conversation

The work of Dr. Sabine Hoffmann, Group Leader of Interdisciplinary and Transdisciplinary (ITD) Research at the Swiss Federal Institute of Aquatic Science and Technology (EAWAG), helped lay the foundations for the Gluon approach. Sabine has extensive experience leading research on water and sanitation innovations, as well as guiding integration efforts across multiple disciplines, fields, and sectors. In this interview with the Gluon team (Johnathan Subendran, Chuma Mbambo-Lado, Anne Bruggen, and Nikki Brand), Sabine reflects on her journey in transdisciplinary knowledge integration, the notable differences between EAWAG integration experts and Gluon researchers, and the challenges both face in the academic realm.

Q: Sabine, your academic work focuses on integration, expertise, and transdisciplinarity, with a particular emphasis on "integration experts." At what point in your career did you realise that this role was essential in transdisciplinary environments?

A: I really realised the need for such a dedicated role when I started working as a postdoc within the Swiss National Research Programme (NRP 61) on sustainable water management. I was leading, along with two colleagues—an engineer and a hydrogeologist—a thematic synthesis process on sustainable urban water and wastewater management. When they approached me to coordinate this process, I agreed but was warned it might be challenging for my career. I responded, "OK, I will do it nevertheless." But if I did it, I wanted to combine it with studying integration because, frankly, I didn't know how to lead integration. I knew more or less what to do, but not how to do it, particularly how to combine the scientific results.

This dual role of leading and studying integration therefore allowed me to reflect on how to combine different perspectives from various disciplines and stakeholders involved in the programme. Eventually, the Swiss National Science Foundation supported this approach, financing my position to explore and implement this hybrid role. That's when I realised the double role required completely different competencies than a more disciplinary-focused role. It's a challenging yet rewarding position, essential if we are

serious about inter- and transdisciplinarity.

Q: You're credited with coining the term "integration expert." Can you tell us more about how that came about?

A: About eight years after my work with NRP 61, Christian Pohl and I submitted a research proposal to the Swiss National Science Foundation to study integration using empirical case studies. We wanted to explore who leads these processes and what their roles entail. During the proposal development, we debated what we call these individuals—integrative leaders, integration specialists, or integration experts. Although the proposal was rejected twice, the idea persisted.

We later organised a workshop at the ITD Conference in Gothenburg in 2019[19], where we used the term 'integration experts/integration specialists' in the title. Only afterwards, when we wrote up the paper, "Integrate the Integrators"[20] did the term "integration expert" start to resonate, especially when we linked it to expertise, which was a key aspect we wanted to highlight. This term stuck because it allows for a connection to the concept of expertise, which is central to the role.

Q: What are the biggest challenges that integration experts face in their work?

A: The challenges vary, and within our group, we usually differentiate them across several dimensions. There's the cognitive challenge, where one must identify and integrate different perspectives from various disciplines. But also, how do you add value in a way that exceeds the sum of its parts? Handling this cognitive overload, ambiguity, and complexity can be daunting.

Then there are social challenges—managing the diverse interests, expectations, and needs of many people and institutions involved in these projects. This also ties into emotional challenges, such as creating a climate of trust, respect, and collaboration. Integration experts often act as emotional buffers, requiring both sensitivity and resilience.

Then, of course, there's a strategic challenge: creating

19. International Transdisciplinarity Conference 2019, Network for Transdisciplinary Research (td-net), accessed January 13, 2025, https://transdisciplinarity.ch/en/veranstaltungen/itd-conferences/itd-ch-19/.

20. Hoffmann et al. 2022, 'Integrate the Integrators'

the necessary conditions for integration, such as securing resources and sometimes creating protected niches where innovative ideas can flourish. Nurturing creativity calls for a delicate balance of inclusion and exclusion.

Q: Are there aspects of the role of the Gluon researcher, as we've described it, that surprised you, or do they align with your experiences?

A: I see a lot of similarities between the way you describe Gluon researchers and the role of integration experts, particularly in designing and implementing integration processes and organising the final results. This aligns with my experience of integration work. However, we differ when it comes to ownership of collaborative products. In my experience, the final output is typically a shared effort, with contributions from everyone involved.

Now that you mention it, it's interesting to think about the distinction between roles. Sometimes, you have one person acting as the facilitator and another as the observer or contributor. The facilitator helps guide the process without necessarily contributing their own cognitive input, while the other person plays a larger role in bringing their knowledge to the table. This division of labour can shape how ownership is perceived.

Q: What is the single most important skill an integration expert needs?

A: To be honest, rather than specific skills which can be acquired over time, I believe certain personal qualities are crucial: openness to other disciplines, fields, and sectors, for example. Humility is also key, recognising that one's perspective is just one among many. This, along with curiosity and perseverance, forms the foundation for effective integration work. Skills and expertise can be developed along the way, but these personal qualities are the basis for everything.

Q: What makes knowledge integration unconventional in a traditional academic setting?

A: Integration work requires stepping away from the "business as usual" routine of disciplinary research.

Interdisciplinary and transdisciplinary work demands new methods, tools, and collaborative approaches that many researchers aren't accustomed to. The diversity of disciplines and stakeholders involved inevitably leads to conflicts, as everyone has different interests and expectations. Navigating these challenges requires a departure from the traditional academic mindset.

Q: Can you provide examples of new types of integrative products that go beyond traditional academic outputs?

A: This is linked to what I said before, about creating protected niches: this example is from a research programme, in which PhDs and postdocs created an animated film on sustainable water and wastewater management. This was one of the integrated outputs that resulted from the collaborative synthesis effort within the programme. Other examples include policy briefs with practical recommendations and even comics that humorously depict challenging situations in integration work. We try to balance these alternative outputs with traditional peer-reviewed publications. For instance, we've integrated alternative outputs into PhD theses, like including comics as part of the thesis package alongside traditional publications.

Q: We often try to explain what Gluons do or what integration experts accomplish, but these descriptions can be difficult for people unfamiliar with this jargon. Do you use any metaphors or analogies to describe the work of integration that are more relatable and easier to understand?

A: I sometimes use the metaphor of "orchestrating" to describe integration. It might overemphasise the idea of bringing things together, but it works for me because it captures its essence: Just like an orchestra, integration requires collaboration among various parts, and this collaboration has to be directed and facilitated by a conductor of sorts. The conductor (or the integration expert) has to overlook the various parts being brought together and navigate complex dynamics in the orchestra similar to those found in ITD projects, but the integrated outcome depends on the collaborative effort of the whole group.

Experience

Gluons on the Gluon

Johnathan Subendran[1]
Chuma Mbambo-Lado[1]
Anne Bruggen[1]

21. Gluon Team: Anne Bruggen (AB), Chuma Mbambo (CM), and Johnathan Subendran (JS)

What drove you to become a Gluon researcher?

AB: I graduated from the AMS Institute, which sought to solve complex urban challenges (mobility, energy, climate resilience, circularity, food systems, and responsible digitization) through deep collaboration between highly diverse disciplines ranging from architects and urban designers to political scientists, biologists, and civil engineers. By designing the master's programme based on urban challenges rather than on disciplinary orientation, the institute took a novel approach to sustainability education. However, there was no established career path for the ITD skill set the programme cultivated. Upon finishing my master's degree, I found myself returning to the comfort of my own discipline—design. After two years of working in landscape architecture, I came across the role of Gluon Researcher, and it felt like a revelation. A position focused on 'knowledge integration' was exactly the kind of work I'd been searching for but didn't know existed yet.
As a Gluon, I am driven by the challenge of getting to the heart of complex problems, understanding them from multiple perspectives, and contributing to truly sustainable solutions. This role embodies what I believe is essential for the transition to a sustainable future: an integrative approach that breaks down silos and bridges disciplines to reconfigure knowledge in unprecedented constellations. Our current siloed methods aren't working—so what is the right approach? That's the question I am exploring as a Gluon, striving to make the most impactful, sustainable contribution I can from a scientific and integrative perspective.

CM: During my five years as an Urban Planner and researcher in practice, I worked in multi-disciplinary settings and was often part of task teams that developed "integrated development plans or strategies." Although these were carefully thought out, the outcomes we worked towards did not always result in uniform actions from the different sectors and disciplines and thus did not always yield the anticipated impact. Inevitably so, because the different partners often came from diverse sectors with

diverse expectations and ways of working. It goes without saying that in this very complex world, we need to work in an integrated way to achieve positive societal impact. The idea of conducting this process really spoke to me. The role I applied for focused on health and well-being inequalities, which seemed like a good fit since I had previously worked on spatial justice and urban inequality issues in South Africa.

JS: As a trained architect and urbanist, I have been tasked with dealing with complexity all throughout my academic and professional career. For designers, space is a medium for integrating certain demands and questions, and Gluons play a similar role. Instead of designing an urban area that satisfies the needs of different inhabitants, I now develop propositions that unite various disciplines. My background meant I felt perfectly suited for this novel and experimental role, with all its ambiguity and mystery. As an intellectually curious person, I felt it would be an exciting new way to explore my skills and apply my toolset in a different environment.

What has been your key takeaway as a Gluon researcher so far?

JS: I have applied the Gluon approach in two consortia: one focused on identifying shared and unshared perspectives amongst peers in international deltas (ReDesigning Deltas)[22] , and the other on the flood-resilient development of the Maasterras area in the municipality of Dordrecht.[23] In both, I implemented a Gluon procedure[24] that ran parallel to several other research and design efforts, iteratively generating, digesting, and reflecting to produce my integration report. Both cases addressed spatial development, knowledge integration, and spatial design.

My biggest takeaway so far is that knowledge integration in spatial development and redevelopment projects may, in fact, be unjust. Several disparities can be observed within the integration process. First, certain participants' knowledge may be prioritized or excluded due to biases and limited integration capacity. For example, knowledge holders may be treated unequally due to their disciplinary affiliation or

22. The Gluon's role within Redesigning Deltas was to harness existing knowledge on delta resilience through collaborative learning and knowledge integration. By engaging researchers, designers, and policymakers from seven delta contexts, the project examines pathways for convergence that incorporate thematic analysis, conceptual mapping, and integration through leadership. The goal is to strengthen delta systems' capacity to adapt to climate change, infrastructure challenges, and socio-environmental pressures.

23. The Dordrecht Maasterras project focuses on developing a climate-adaptive and safe shelter area that integrates flood safety, disaster resilience, and infrastructure management. By incorporating diverse stakeholder perspectives, including municipal authorities, engineers, urban designers, and local residents, the project aims to create an adaptive framework that enhances the area's capacity to withstand climate-related risks while maintaining social inclusivity and sustainability.

24. A procedure designed to create integrated output, by a gluon researcher. Process design of these procedures considers a series of tailored methods and allows for practical and scientific reflection on integration. Since our empirical knowledge base for understanding integration is limited, gluon procedures currently need to be tailor-made for each occassion.

their position relative to dominant disciplinary biases. I encountered this in the Maasterras project when, during the integration process, the client and designers valued technocratic solutions and perspectives more than socially oriented expertise in areas such as social cohesion. As a result, the decisions were also skewed by a technocratic bias.

Second, inclusive participation is often limited by the communication methods used in integration. Certain prerequisites—such as the ability to interpret design maps or the confidence to speak in large working groups—can restrict expert engagement. These disparities hinder integration and perpetuate fragmentation, contributing to knowledge, or epistemic injustice: the ways in which knowledge is selected, who participates, and which forms of knowledge are valued during integration.

From my experience as a Gluon, moving toward equitable and just knowledge integration requires acknowledging that the process is not neutral. It is shaped by factors across different scales: collaboration, project intervention, and individual cognitive biases, many of which are hard to change. To address these structural biases, transparency and accountability in knowledge integration must be made more explicit. This includes clarifying who is involved, how decisions are made, and what perspectives are prioritized or dismissed. Additionally, positionality—the ways in which one's background, disciplinary training, and institutional affiliations influence knowledge integration—needs to be actively recognized rather than overlooked. Without explicit awareness of these dynamics, integration efforts risk reinforcing existing power imbalances rather than challenging them.

While I am still grappling with this complex issue and don't yet have definitive answers, I believe that the first step toward more just knowledge integration is to recognize its subjectivity. Acknowledging that integrative work is influenced by institutional, political, and cultural contexts—and is therefore susceptible to bias—is essential for making progress.

CM: While I always have been aware that knowledge integration is no easy task, being a Gluon has deepened my understanding of why it remains so uncommon. Research consortiums often have varying knowledge integration needs, requiring different levels of technical and scientific integration at different stages. This can range from indirect knowledge integration, which involves ensuring consortium members are aware of each other's work, sharing and exchanging information, and holding regular meetings, to direct knowledge integration, where members use transdisciplinary methods to collectively produce integrated knowledge outputs.

Although both are essential for effective knowledge integration, a Gluon cannot manage integration alone. The consortium into which a Gluon is embedded should therefore work on co-identifying attainable integration outputs and outcomes, identifying the support needed for effective knowledge integration, and give space to experiment with methods that promote a more holistic approach to producing knowledge that can be utilized by diverse knowledge holders across different areas of impact.

Since I have applied the Gluon approach to the consortia of SPRING,[25] Resilience on the Labour Market and JUST GREEN[26], I have also been able to make preliminary interdisciplinary observations on the domain of urban health and well-being. Health and well-being inequalities can be experienced at both systemic (environment and policy) and individual (values and lifestyle) levels, and therefore interventions are required at both levels to improve health outcomes. Overall, I have noticed that the concept of 'the opportunity structure' has the potential to connect and accelerate collective learning regarding urban well-being. Finally, I have become interested in the role of complex values and power dynamics in ITD consortia and how they affect the evolution of these consortia. It is my hypothesis that understanding and managing diverse value systems and power relations are crucial for enhancing the stability and resilience of transdisciplinary consortia.

25. The *SPRING Consortium* advances societal resilience by addressing health inequalities in the neighbourhoods of Rotterdam. The consortium aims to apply transdisciplinary methods to understand the complex factors contributing to health inequalities and well-being in marginalised neighbourhoods. SPRING explores how physical and social environments shape well-being, integrating knowledge from academia, policy, practice and experiential knowledge from residents in a living-lab format. SPRING contributes to the Dutch Life Sciences & Health mission, aiming to give Dutch residents five additional years of good health and a 30% reduction in health disparities by 2040.

26. JUSTGREEN explores ways to make urban greening efforts more equitable and inclusive, prioritising vulnerable communities disproportionately affected by climate change. By working with municipalities across Europe (Tallinn, Ghent, Katowice, Rotterdam, Murcia, Burgas, Attica), urban planners and community organizations, the project develops policy frameworks that integrate social equity principles. The approach emphasises learning at individual, relational, and community levels to foster fair and sustainable green infrastructure interventions.

27. The dedicated time needed within a consortium to work together in knowledge holder groups to produce integrated outputs. The gluon team estimates this at a minimum of 30%. Without a dedicated portion of collective time (to work on these integrated deliverables) that is secured upfront and agreed upon by the consortium members, integration efforts are more likely to fail.

AB: as a Gluon researcher, my key insight so far has been the essential role of "collective time" in knowledge integration processes in consortia. Facilitating long-term, structured collaboration—especially over 1-2 years—requires deliberate design and sustained commitment to time spent in smaller integration groups. This is often difficult to secure when immediate, tangible rewards aren't apparent. Yet, this dedicated time is crucial, not just for exchanging thoughts but for synthesising ideas in a structured manner. I've learned that this "collective time"[27] —such as working together on a 'boundary object' or 'integration artefact'— often stretches beyond initial expectations and is rarely fully financed. In academia, this happens because funding mechanisms tend to prioritise specialist outputs such as scientific articles over broader integrative work, which may not result in traditional deliverables. In practice, knowledge holders are often not compensated for their time, reducing their incentive to participate fully.

One of the main challenges is balancing this collective time across diverse tasks, disciplines, and perspectives. It requires intentional process design, fostering productive interactions while ensuring participants aren't overwhelmed. The work of a Gluon is like weaving a tapestry of various threads, representing different forms of knowledge. In that sense, ITD collaborations resemble a rich and variegated carpet made of various yarns —some are thick, some thin, some vibrant, others more muted, and they even differ in texture. Rather than forcing integration from the outset, the goal is to create a structured environment where transdisciplinary collaboration evolves naturally. These threads can then be woven together incrementally, allowing each expert to contribute meaningfully while starting from the safety of their own perspective.

Continuous validation through iterative cycles is crucial for ensuring that interactions during "collective time" are productive. These cycles keep stakeholders engaged, justify the investment of time and resources, and ensure alignment with the collective's evolving goals. It's also essential to establish, from the outset, a mutual understanding that

every participant's contributions—both time and intellectual input—are necessary for achieving truly integrative outcomes. My work with Red & Blue[28] and JUSTGREEN has reinforced this approach. Integrated solutions to complex problems can only be identified and developed when collective time is properly structured, consciously designed, and adequately funded. Without this, even the most well-intentioned collaborations struggle to achieve genuinely transdisciplinary outcomes.

28. Red & Blue investigates how interdisciplinary and transdisciplinary knowledge production can enhance integrated real estate and infrastructure climate risk management. The project collaborates with governmental water management agencies, real estate developers, urban planners, and community stakeholders to develop adaptive, long-term strategies for living with water in the Netherlands. Through iterative learning processes and action labs, the project seeks to establish boundary objects that connect diverse disciplines and sectors.

Questions

Frequently asked questions

A public service announcement by the Gluon team

Are Gluon researchers academics?

Yes. Just like traditional disciplinary work, Gluon research relies heavily (and perhaps even more so) on critical and highly abstract thinking. Gluons spend relatively more time combining concepts and approaches from many different angles than disciplinary experts, who spend more time on gathering and analysing empirical evidence to test a hypothesis.

Do you need a Gluon?

Gluon researchers are integration experts who are most valuable in groups of knowledge holders where a large distance needs to be bridged to reach a collective understanding and where complex societal challenges or 'wicked problems' are studied. Some integrative efforts can be performed by other 'integrators', such as facilitators or project officers. An example of this is activities in which knowledge holders are encouraged to exchange knowledge, but it is not necessary to capture the collective learnings on the problem domain. The larger coordination load in ITD consortia (agendas, meetings, agreements) does not specifically require a Gluon. Gluons are remarkable in the sense that they actively experiment with methods for knowledge integration, with the aim of building a scientific toolbox to accelerate collective learning. They, therefore, both apply and study integration. Apart from the question of if they 'need' a Gluon – visualised in this diagram – consortia need to be able and willing to accommodate such a role. Like all researchers, Gluons need time from and access to knowledge holders, support from principal investigators and most importantly, feedback from participants in their procedures.

Where did the Gluon approach come from?

The Gluon approach originated from engineering and design-thinking practices at the Delft University of Technology, particularly from the efforts of the Delft Deltas Infrastructures and Mobility Initiative (DIMI) that

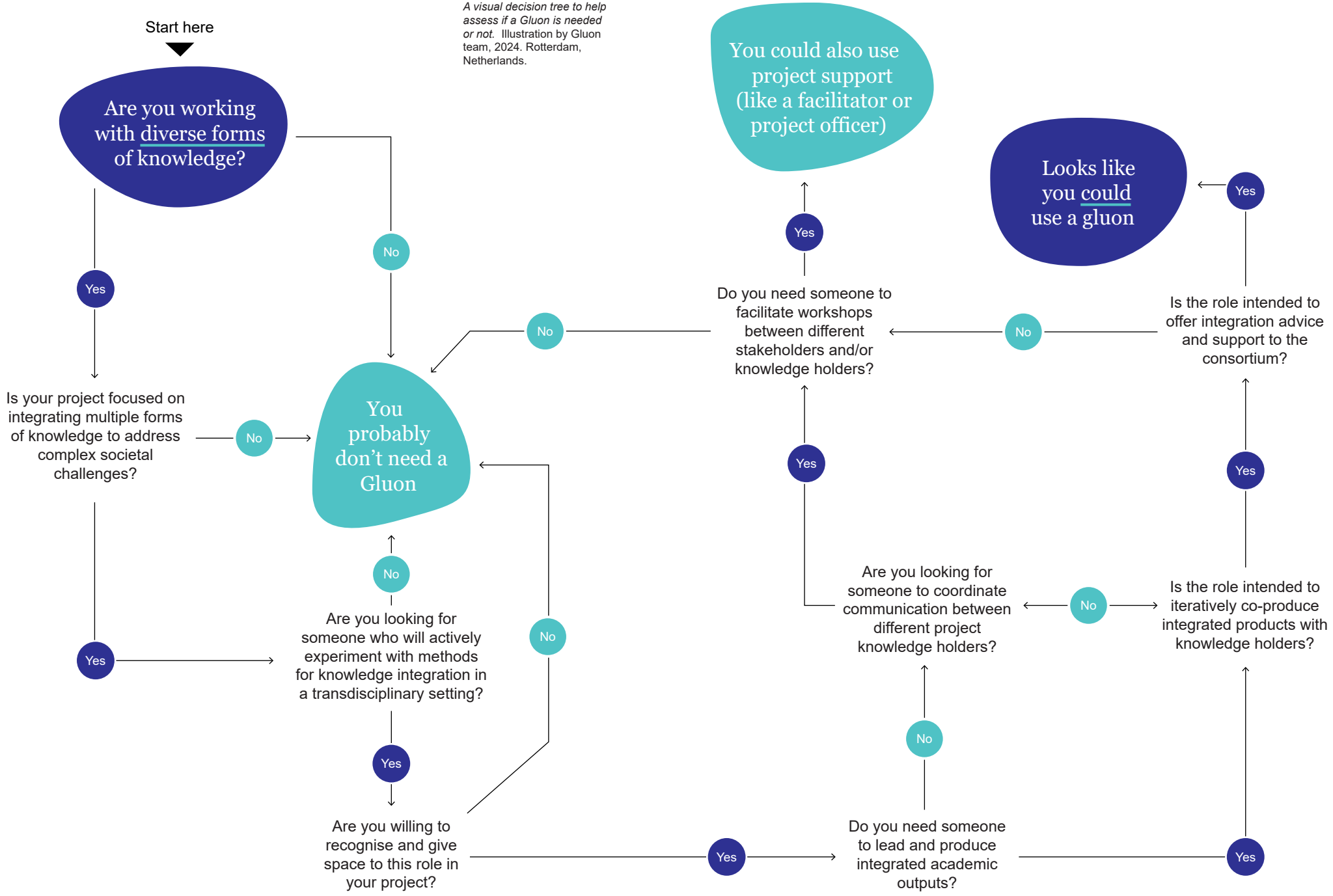

Fig. 4. *Do you need a Gluon? A visual decision tree to help assess if a Gluon is needed or not.* Illustration by Gluon team, 2024. Rotterdam, Netherlands.

funded and studied transdisciplinary collaboration between academics and practitioners from public and private institutions with an engineering background. Common concepts such as loose coupling and phasing of integrated design processes for wicked problems were combined with insights from the academic field of Interdisciplinarity and Transdisciplinarity (ITD), including on integration experts and expertise, giving rise to the Gluon approach.

Are Gluon researchers facilitators who I can book for workshops?

No, Gluon researchers are more than facilitators. They also develop individual knowledge about the problem domain that is studied by the groups they lead. The Gluon approach authorises researchers to chart unknown territory beyond the scope of existing knowledge with the support of a group, unlocking collective research directions that would otherwise be unavailable for disciplinary experts alone. Gluon researchers therefore make an individual intellectual contribution to the problem domain while also facilitating collaborative learning.

Why do Gluon researchers produce multiple integration reports before arriving at their final deliverable?

Like traditional academic researchers, Gluon researchers need quality control. Established academic disciplines have peer review as their main quality control mechanism, which involves researchers in the same or similar fields assessing the quality (e.g. scientific rigour) of the work. Gluon researchers rely not on peer review but on 'serial review of a diverse group of non-peers', and thus on iteration.
Does the Gluon approach oppose disciplinary knowledge? Absolutely not. The Gluon approach builds on the existence and quality of specialist expertise and aims to access new research territories while protecting experts from overextending themselves and/or suffering reputational damage.

Will the Gluon approach solve integration deficits?

Large consortia have a greater integration deficit than a single Gluon researcher can handle. Gluon work is cognitively labour-intensive and has high social transaction costs: Gluon researchers need to familiarise themselves with many different concepts while building trust in the groups they work with. This means that they can only cover relatively small pockets of integration in a procedure. In our experience, larger consortia (for example, with more than 4–5 working packages executed by a single researcher) need coordination support beyond Gluon work.

Gluons are not new, they are basically just designers, system engineers or action researchers.

The Gluon approach shares traits with, and stands on the shoulders of, many existing forms of integrative practice, action research, systems thinking and boundary-crossing theory. In that sense, it is indeed not new. What we believe to be novel additions are the application of an iterative approach to wicked problems with the explicit purpose of overcoming problem and solution bias (doing integration), and the simultaneous monitoring of the effectiveness of the approach (studying integration).

About the contributors

Authors

Nikki Brand is Academic Lead Methodology at the Resilient Delta initiative and creator of the Gluon researcher concept. Nikki started her academic career in geography at TU Delft, with a focus on the evolution of cities. As a postdoc in various multidisciplinary consortia focused on international flood risk management, she experienced both the depth of expertise and the lack of shared understanding between different fields. Having discovered the emerging fields of interdisciplinarity and transdisciplinarity (ITD) and integration expertise, her current work focuses on building a niche in which integration experts can evolve and grow.

Johnathan Subendran is a Canadian-born Eelam Tamil spatial designer and Gluon PhD researcher at the Resilient Delta initiative. His work focuses on justice in design processes and is particularly interested in how positionality, biases and uneven power dynamics in integration roles contribute to fragmented and unfair knowledge integration, also known as epistemic injustice. Through action research and critical design ethnography, he explores how positionality and bias affect integration in design processes and create concerns for design justice in transdisciplinary settings. By challenging exclusionary practices and fostering integrative accountability, his work aims to create more just knowledge integration processes and equitable outcomes in transdisciplinary settings, promoting knowledge integration for design justice.

Chuma Mbambo-Lado is a Gluon researcher focusing on urban health inequalities and well-being at the Resilient Delta initiative of the Convergence Alliance. Chuma has a background in strategic urban planning and focuses on inclusive urban strategies in various greening, smart cities and informal economy projects in South African cities. As a Gluon researcher, she is interested in the role of complex values and power dynamics between diverse stakeholders in transdisciplinary research collaborations on urban health and well-being. In this first booklet, Chuma reflects on some of her experiences in this pioneering role.

Anne Bruggen works as a Gluon researcher in the Resilient Delta initiative research programme. Anne's work is driven by a passion for creating equitable, sustainable urban spaces that balance ecological and human needs. Her career is dedicated to advancing sustainability in the built environment, spanning the design of modular timber housing details to nature-inclusive and climate-adaptive courtyards. With a focus on transdisciplinary approaches to urban ecology, she has worked as a researcher on integrating ecological perspectives into large-scale infrastructure projects. Currently, Anne's research centres on climate justice in urban environments, exploring spatial and financial dynamics in initiatives such as JUSTGREEN and Red & Blue. Her methodological focus lies on bridging the problem-solution bias by reconciling research and design methods in transdisciplinary collaborations.

Interviewee

Dr. Sabine Hoffmann is a distinguished senior researcher at EAWAG and an affiliate researcher at ETH Zurich, specialising in transdisciplinary research and sustainability science. Her work focuses on integrating scientific disciplines and stakeholder perspectives to tackle environmental challenges, particularly in sustainable water management. Hoffmann co-developed the concept of the "integration specialist" with Christian Pohl, emphasising the importance of synthesising knowledge in interdisciplinary and transdisciplinary teams. As a mentor and leader in large-scale projects such as the Swiss NRP 61, she combines practical collaboration with reflective research to advance sustainability solutions.

Reviewers

Dr. Lieke Oldenhof is an Associate Professor at the Erasmus School of Health Policy and Management and a member of the coordination committee for the Resilient Delta initiative's Methodology theme. Her research focuses on how citizens, professionals, and public managers reconfigure welfare systems to address rising health inequalities in cities and communities. She co-founded the CARE Lab Rotterdam to advance participatory action research for integrated citizen support. As a reviewer of the first issue of the Gluon Booklet Series, Oldenhof draws on her expertise in transdisciplinary research and governance to ensure the publication reflects the uniqueness of the Gluon concept in the inter- and transdisciplinary landscape.

Dr. Steven Flipse is an Assistant Professor at TU Delft, focusing on transdisciplinary collaboration and responsible innovation. His research examines how scientists and engineers can integrate diverse viewpoints—spanning societal, economic, and environmental considerations—into their innovation processes. He collaborates with natural scientists, designers, and engineers to understand decision-making in interdisciplinary teams, aiming to promote inclusiveness and ethical reflection in research and development. Flipse reviewed this first publication in the Gluon Booklet Series as a member of the coordination committee for the Resilient Delta initiative's Methodology theme, using his expertise in transdisciplinary research to examine the prospects of the Gluon methodology.

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Figures:

Fig. 1. *The Gluon timeline*. Illustration by Gluon team, 2024. Rotterdam, Netherlands

Fig. 2. *The Gluon team with Nikki Brand (left), Anne Bruggen, Chuma Mbambo-Lado, Johnathan Subendran*. Photo by Cat Stoop, 2023. Rotterdam, Netherlands.

Fig. 3. *Key differences between the established approach(es) and the Gluon approach*. Illustration by the Gluon team, 2024. Rotterdam, Netherlands.

Fig. 4. *Do you need a Gluon? - A visual decision tree to help assess if a Gluon is needed or not*. Illustration by the Gluon team, 2024. Rotterdam, Netherlands.

Colophon

This publication was made possible by Resilient Delta initiative of Convergence Alliance.

Authors
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Reviewers
Lieke Oldenhof and Steven Flipse

Printer
Wilco Art Books

Publisher
TU Delft
Resilient Delta initiative

Proofreading
AVB Vertalingen

Design and layout
Johnathan Subendran

Typeface
Arial
Georgia

ISBN 978-94-6384-761-2

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Resilient Delta initiative:

Resilient Delta (RDi) is one of five initiatives of Convergence, an alliance between TU Delft, Erasmus University Rotterdam and Erasmus Medical Centre. It is a transdiscplinary and interdisciplinary effort that combines research and education to accelerate learning on complex societal challenges in the delta.

Next issue: Gluons in their Consortia

Curious about the Gluon researchers and their products? The next issue describes the learnings of several Gluon collectives focusing on social inequality, urban green, delta resilience and climate finance. ‘Gluons in their Consortia’ will highlight both insights on these problem domains and on integration itself, including phenomena such as integration readiness, the need for collective time for each working package and the occurrence of a Frankenstein Effect in consortium leadership.

The Gluon researcher is a dedicated integration expert who leads the co-creation process of interdisciplinary and transdisciplinary knowledge. This booklet, The Gluon, describes the origins and nature of the Gluon approach and the Gluon researcher role.

Despite the widespread interest in interdisciplinarity and transdisciplinarity (ITD) as a means to address complex problems, many collaborations struggle with an integration deficit that leaves knowledge contributions in relative isolation and prevents ITD from fulfilling its promise.

Gluon researchers have three tasks. They design and implement integrative procedures, author integrated products, and study integrative methods. They therefore simultaneously learn how to co-create knowledge in different settings, while also extracting integrated observations about the problem domains that are studied. Like the elementary particle, a Gluon researcher therefore counterbalances the natural process of fragmentation that occurs when subatomic particles that collectively form a nucleus are not continuously connected. This division of labour reduces the workload of specialists and acknowledges the complementary contribution made by integration expertise in academia. The Gluon approach is therefore meant to radically improve the conditions for ITD.

Ultimately, this booklet serves to inspire ambitious ITD collaborations and calls on other integration experts to reveal themselves and share their expertise.

Resilient Delta initiative ISBN 978-94-6384-761-2