

# ide3a: A Digital Campus for Transdisciplinary Research on Interconnected Urban Critical Infrastructure Systems

Siling Chen<sup>1,1</sup>, Dóra Hegyi<sup>1,1</sup>, Margaux Huth<sup>1,1</sup>, Florian Brokhausen<sup>1,1</sup>, Ongun Türkcüoğlu<sup>1,1</sup>, Philipp Wiesner<sup>1,1</sup>, Jochen Rabe<sup>1,1</sup>, Sangyoung Park<sup>1,1</sup>, Lauritz Thamsen<sup>1,1</sup>, Paweł S. Hachaj<sup>2,2</sup>, Yan Delaure<sup>3,3</sup>, Franz Tscheikner-Gratl<sup>4,4</sup>, Andrea Castelletti<sup>5,5</sup>, Jossekin Beilharz<sup>6,6</sup>, Paul Uwe Thamsen<sup>1,1</sup>, and Andrea Cominola<sup>1,1</sup>

<sup>1</sup>Technische Universität Berlin

<sup>2</sup>Cracow University of Technology

<sup>3</sup>Dublin City University

<sup>4</sup>Norwegian University of Science and Technology

<sup>5</sup>Politecnico di Milano

<sup>6</sup>Hasso Plattner Institute

November 30, 2022

## Abstract

Urbanization and climate change are exacerbating stress on aging urban critical infrastructure systems, including water, energy, mobility, and telecommunication networks. Simulation tools and scenario analyses able to capture the interdependencies among these different infrastructure systems are crucial to support decision making and realize sustainable and resilient development. Yet, existing simulation tools are mostly developed within the boundaries of individual application sectors and information often remains siloed, despite the increasing data and computational opportunities offered by the digital transformation of many infrastructure sectors. In this work, we present how the ide3a project (international alliance for digital e-learning, e-mobility and e-research in academia – <https://ide3a.net>) addresses this research gap. ide3a is building a digital campus to support digital learning, research, and mobility in collaboration within a network of six European partner universities. Several senior and early career researchers with multidisciplinary backgrounds in water management, IT systems, mobility, energy, urban planning, sustainability, and psychology, work together to integrate state-of-the-art research on critical infrastructure and digitalization into traditional higher education curricula. As part of the ide3a portfolio of digital tools for learning and research, we present a prototype of “ConnectiCity”, an open-source simulation-based serious game that integrates multi-sectoral models to perform simulations of interconnected critical infrastructure systems and quantify cascading effects under various climate, social, and technical scenarios. Along with other ide3a activities, it is used to train early career researchers and students alike to enrich their transdisciplinary knowledge, foster critical system thinking, drive research on urban critical infrastructure dynamics, and ultimately working across disciplines to tackle contemporary urban challenges.

# ide<sub>3</sub>a : A Digital Campus for Transdisciplinary Research on Interconnected Urban Critical Infrastructure Systems



**Siling Chen**<sup>1,2</sup>, **Dóra Hegyi**<sup>1,2</sup>, **Margaux Antonia Huth**<sup>1,2</sup>, **Florian Brokhausen**<sup>1</sup>, **Ongun Türkcüoglu**<sup>1,2</sup>, **Philipp Wiesner**<sup>1</sup>, **Jochen Rabe**<sup>1,2</sup>, **Sangyoung Park**<sup>1,2</sup>, **Lauritz Thamsen**<sup>1</sup>, **Paweł S. Hachaj**<sup>3</sup>, **Yan Delauré**<sup>4</sup>, **Franz Tscheikner-Gratl**<sup>5</sup>, **Andrea Castelletti**<sup>6</sup>, **Jossekin Beilharz**<sup>7</sup>, **Paul Uwe Thamsen**<sup>1</sup> and **Andrea Cominola**<sup>1,2</sup>

December 16, 2021





# ide<sub>3</sub>a

international alliance  
for digital **e-learning**,  
**e-mobility** and **e-research**  
in academia

DAAD

Deutscher Akademischer Austauschdienst  
German Academic Exchange Service



Federal Ministry  
of Education  
and Research



## . RESEARCH-BASED TEACHING

- Interdisciplinary topic “Critical Infrastructure & Digitalization”
- Digital education platforms (Moodle)
- Digital tools, incl. a new serious game **ConnectiCity**



ide<sub>3</sub>a-Ambassadors



E-learning Analyst

Icons created by Delwar Hossain, Gregor Cresnar from the Noun Project



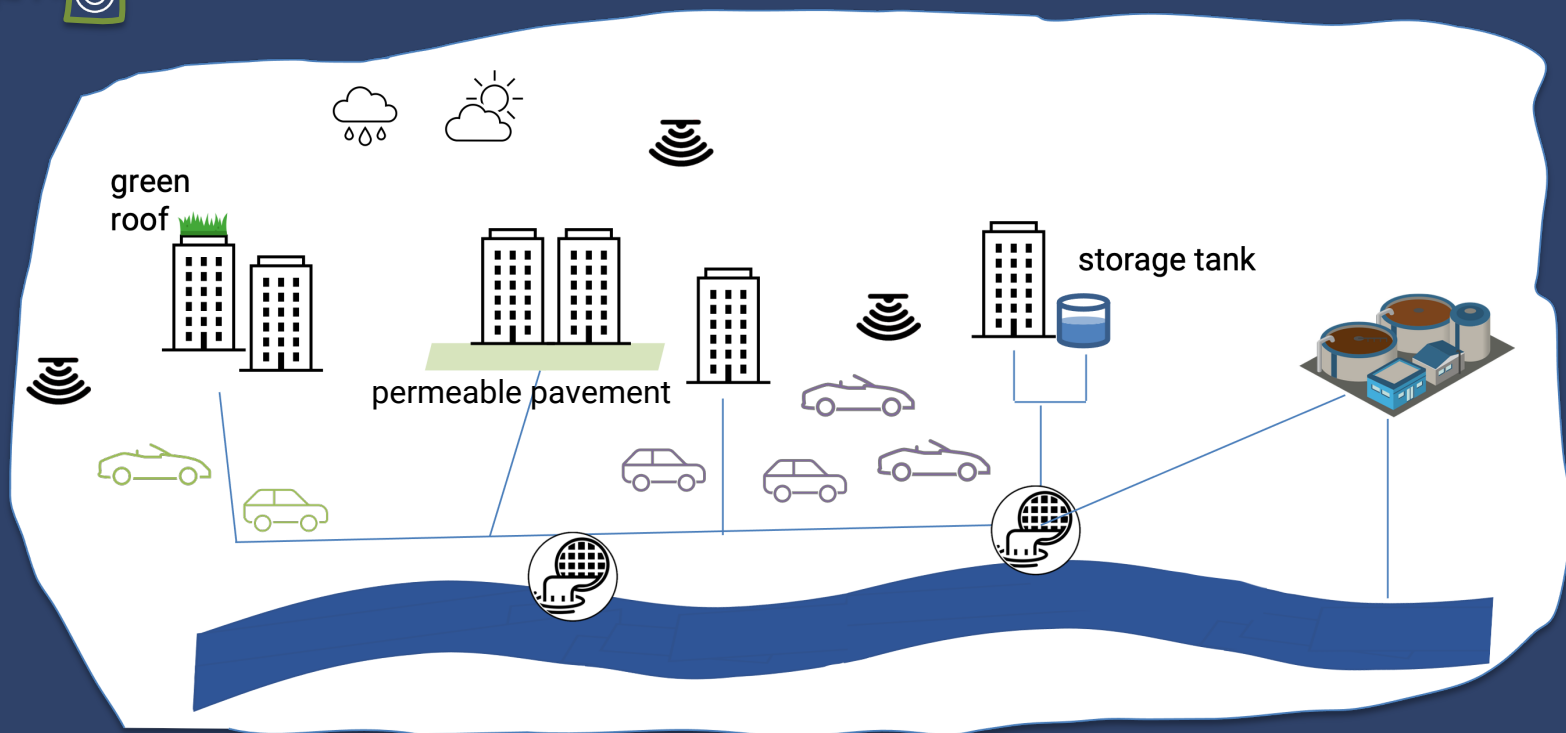


## ConnectiCity

- Open-source, simulation-based serious game
- Integrates multi-sectoral models
- Simulates interconnected critical infrastructure systems
- Quantifies cascading effects under various climate, social, and technical scenarios



Credits: SWN TU Berlin

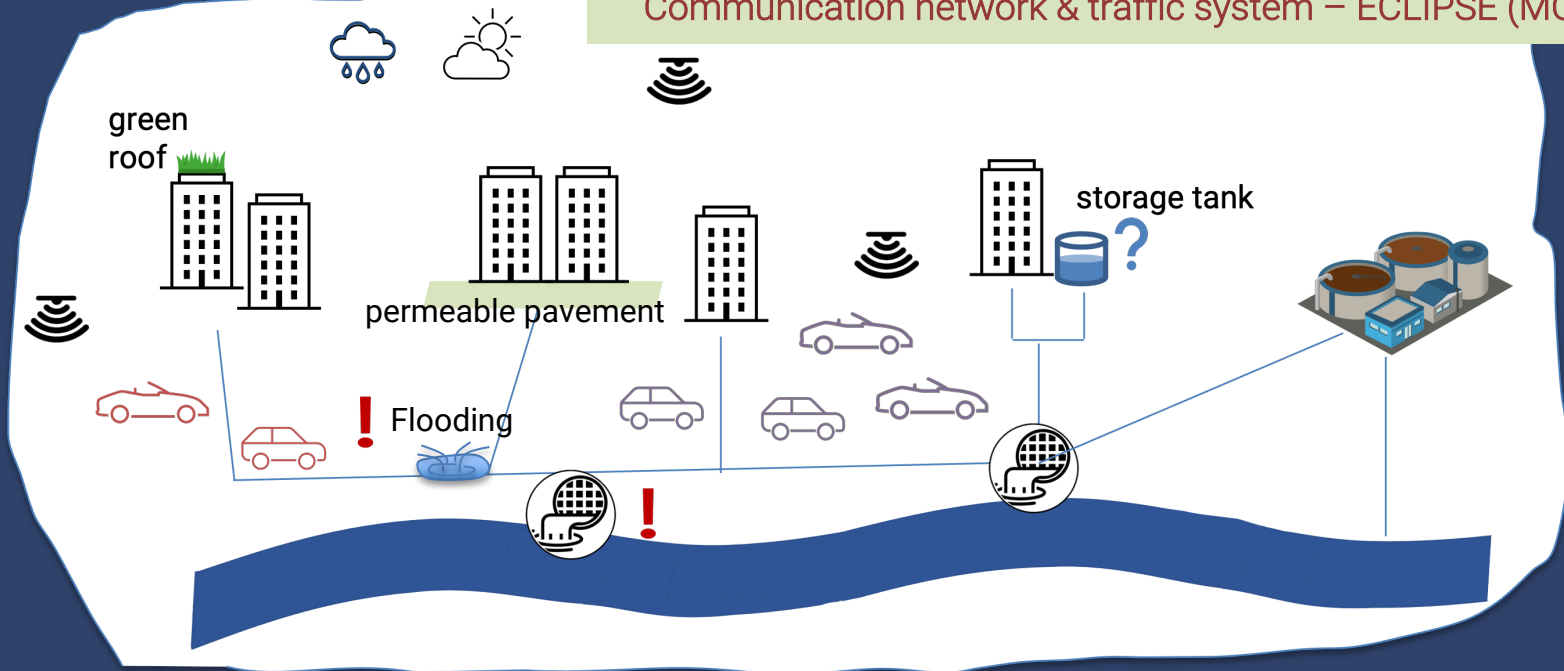


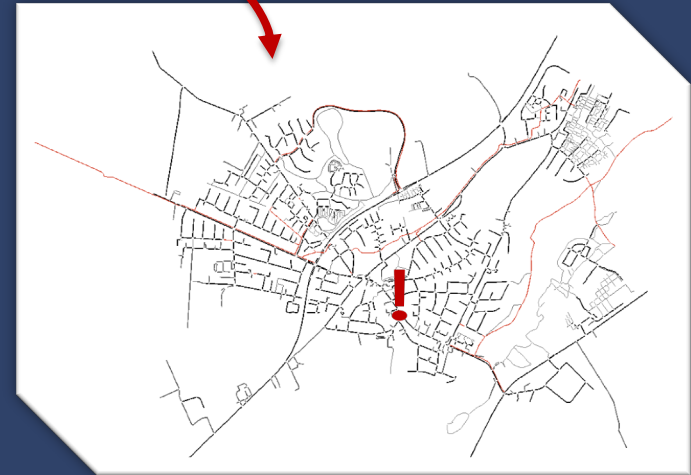
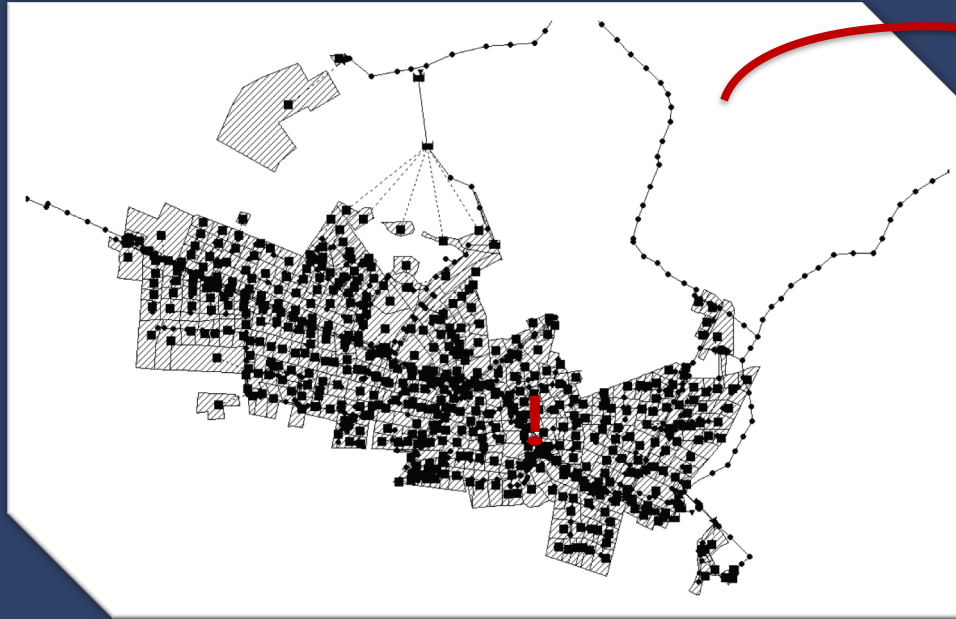
Icon of CSO from <https://www.blue-siren.com/collections/overflow-alarming>, WWTP from <https://pngio.com/images/png-a2274640.html>



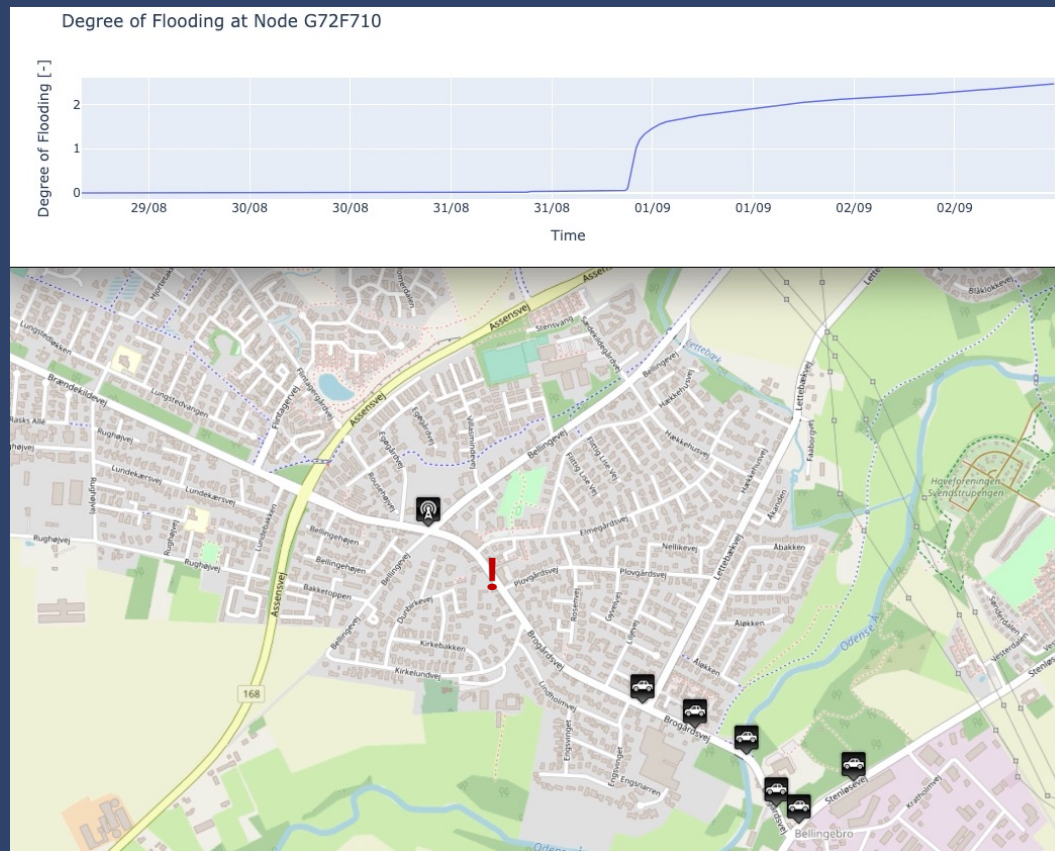
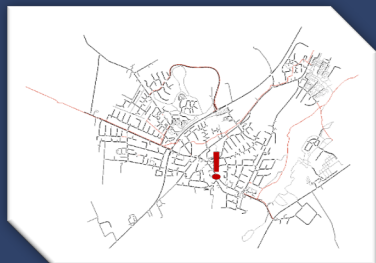
Stormwater (BGI, CSO, flooding) – SWMM<sup>1</sup>

Communication network & traffic system – ECLIPSE (MOSAIC)<sup>2</sup>



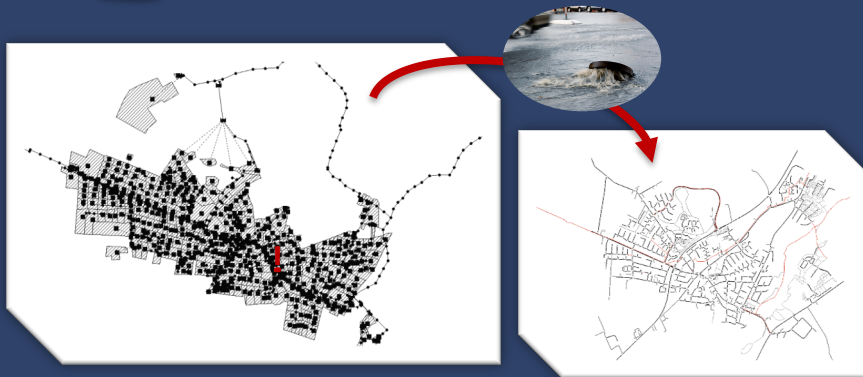


Source: Pedersen, A.N., Pedersen, J.W., Viguera-rodriguez, A., Brink, A., Borup, M., Mikkelsen, P.S., 2021. The Bellingue data set: open data and models for community-wide urban drainage systems research 1–28; <https://www.insblogs.com/catastrophe/frank-sewer-backup-basement-flooding/486>



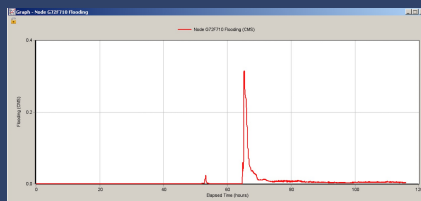


# Digital Campus & ConnectiCity



Workshops from the course **Critical Infrastructure and Digitalization**, 2021

- Stormwater management X Blue Green Infrastructure
- Avoiding hazardous traffic environments via V2X



**Smart City Hackathon**, 2021

- Challenge: couple street inundation models with SWMM

Source: Pedersen, A.N., Pedersen, J.W., Viguera-rodriguez, A., Brink, A., Borup, M., Mikkelsen, P.S., 2021. The Bellinge data set: open data and models for community-wide urban drainage systems research 1–28. <https://www.insblogs.com/catastrophe/frank-sewer-backup-basement-flooding/486>, <https://www.epa.gov/water-research/storm-water-management-model-swmm>



## “Critical Infrastructure and Digitalization”, summer 2021

Digital Water Networks and Interconnected Urban Infrastructure

– Prof. A. Cominola<sup>1,2</sup>

Future Pumping Stations

– Prof. P. U. Thamsen<sup>1</sup>

Modern Leakage and Erosion Monitoring

– Prof. K. Radzicki<sup>3</sup>

Digital Water City Project

– Dr. H. Schwarzmüller<sup>4</sup>



Digitalization of Urban Energy Systems

– Prof. R. Streblow<sup>1</sup>

Peer-To-Peer Energy Communities

– Dr. L. Ableitner<sup>5</sup>



Smart Energy Management of Electric Vehicles

– Prof. S. Park<sup>1,2</sup>

Decentralized Optimization of Intelligent Transportation Systems

– Prof. M. Liu<sup>6</sup>

Continuously Testing IoT Systems

– Dr. L. Thamsen<sup>1</sup> and J. Beilharz<sup>7</sup>

NebulaStream: IoT Stream Processing

– Dr. S. Zeuch<sup>1</sup>

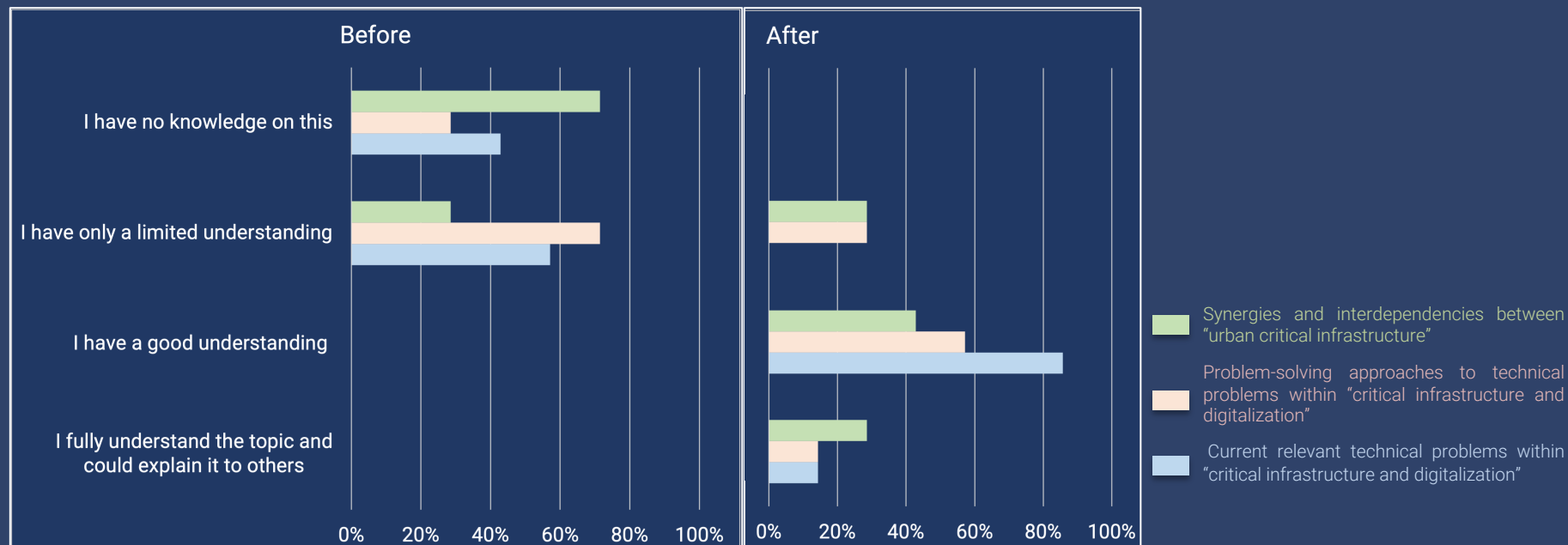
Social Media for Understanding City Dynamics

– Prof. M. Brambilla<sup>8</sup>



# Digital Campus – Achievements

Survey results from pre and post participation of the course "Critical Infrastructure and Digitalization", 2021





# Digital Campus – Achievements



- ✓ 3 new courses + 2 hackathons
- ✓ ~160 students attending the ide3a courses (3 semesters)
- ✓ 12 scholarships awarded (first edition)
- ✓ NEW partnerships established



“I value this experience deeply, and I am hoping for the success of the ide3a team and the other scholars in their futures.”

- Carlos Muli (DCU student)





# ide<sub>3</sub>a

international alliance  
for digital **e-learning**,  
**e-mobility** and **e-research**  
in academia



## Envision



## Challenges

WHICH learning formats? (digital/blended/classroom)

HOW TO measure effectiveness of research-based learning?

WHAT are the lessons learned in providing effective training programs to students with very heterogeneous backgrounds?



# Thank You

ide<sub>3</sub>a



@Ide3a1

[www.ide3a.net](http://www.ide3a.net)

Siling Chen and the ide<sub>3</sub>a Consortium

[siling.chen@tu-berlin.de](mailto:siling.chen@tu-berlin.de)

DAAD

Deutscher Akademischer Austauschdienst  
German Academic Exchange Service



Federal Ministry  
of Education  
and Research

# ide<sub>3</sub>a : A Digital Campus for Transdisciplinary Research on Interconnected Urban Critical Infrastructure Systems



**Siling Chen**<sup>1,2</sup>, **Dóra Hegyi**<sup>1,2</sup>, **Margaux Antonia Huth**<sup>1,2</sup>, **Florian Brokhausen**<sup>1</sup>, **Ongun Türkcüoglu**<sup>1,2</sup>, **Philipp Wiesner**<sup>1</sup>, **Jochen Rabe**<sup>1,2</sup>, **Sangyoung Park**<sup>1,2</sup>, **Lauritz Thamsen**<sup>1</sup>, **Paweł S. Hachaj**<sup>3</sup>, **Yan Delauré**<sup>4</sup>, **Franz Tscheikner-Gratl**<sup>5</sup>, **Andrea Castelletti**<sup>6</sup>, **Jossekin Beilharz**<sup>7</sup>, **Paul Uwe Thamsen**<sup>1</sup> and **Andrea Cominola**<sup>1,2</sup>

December 16, 2021





# ide<sub>3</sub>a

international alliance  
for digital **e-learning**,  
**e-mobility** and **e-research**  
in academia

DAAD

Deutscher Akademischer Austauschdienst  
German Academic Exchange Service



Federal Ministry  
of Education  
and Research



## . RESEARCH-BASED TEACHING

- Interdisciplinary topic “Critical Infrastructure & Digitalization”
- Digital education platforms (Moodle)
- Digital tools, incl. a new serious game **ConnectiCity**



ide<sub>3</sub>a-Ambassadors



E-learning Analyst

Icons created by Delwar Hossain, Gregor Cresnar from the Noun Project



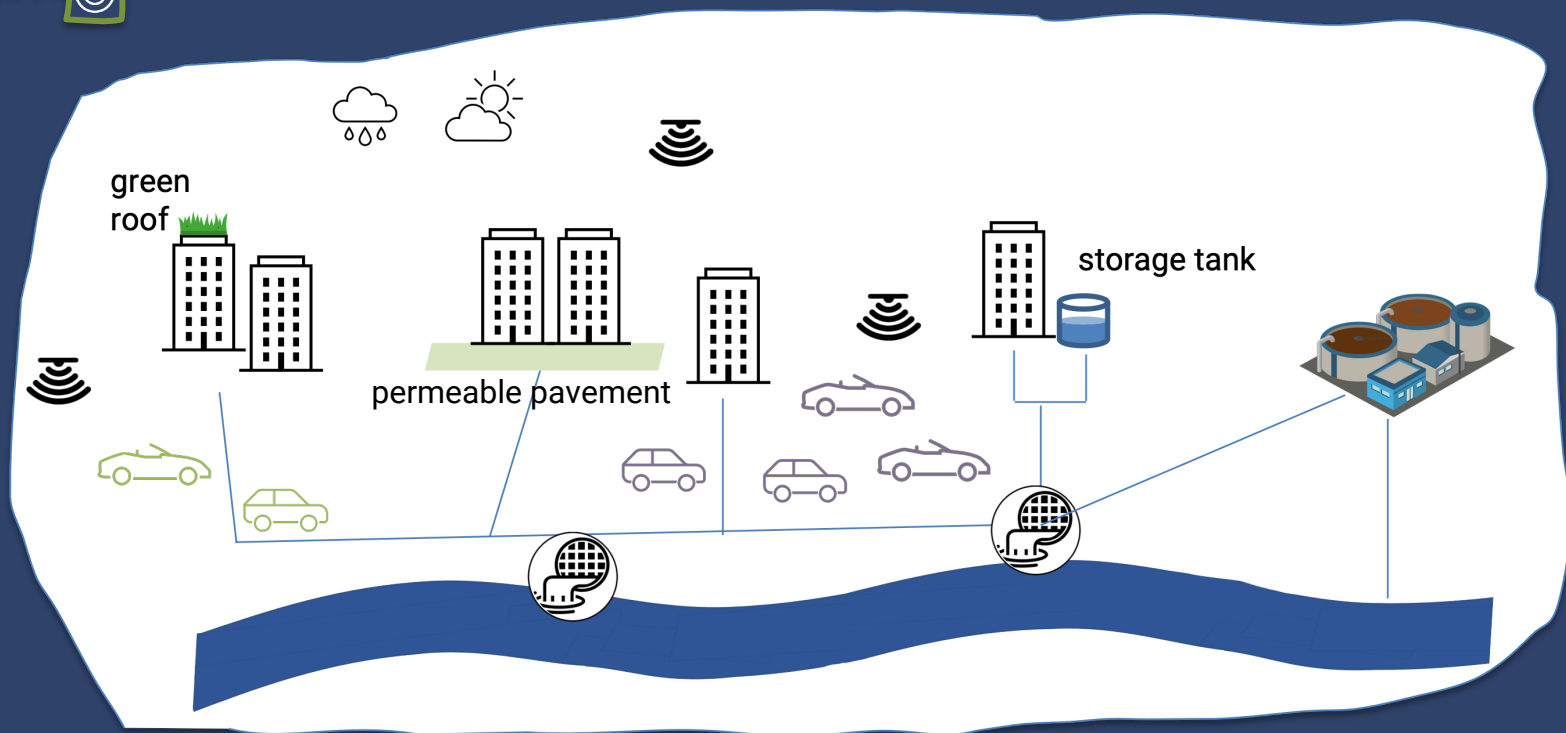
## ConnectiCity

- Open-source, simulation-based serious game
- Integrates multi-sectoral models
- Simulates interconnected critical infrastructure systems
- Quantifies cascading effects under various climate, social, and technical scenarios



Credits: SWN TU Berlin



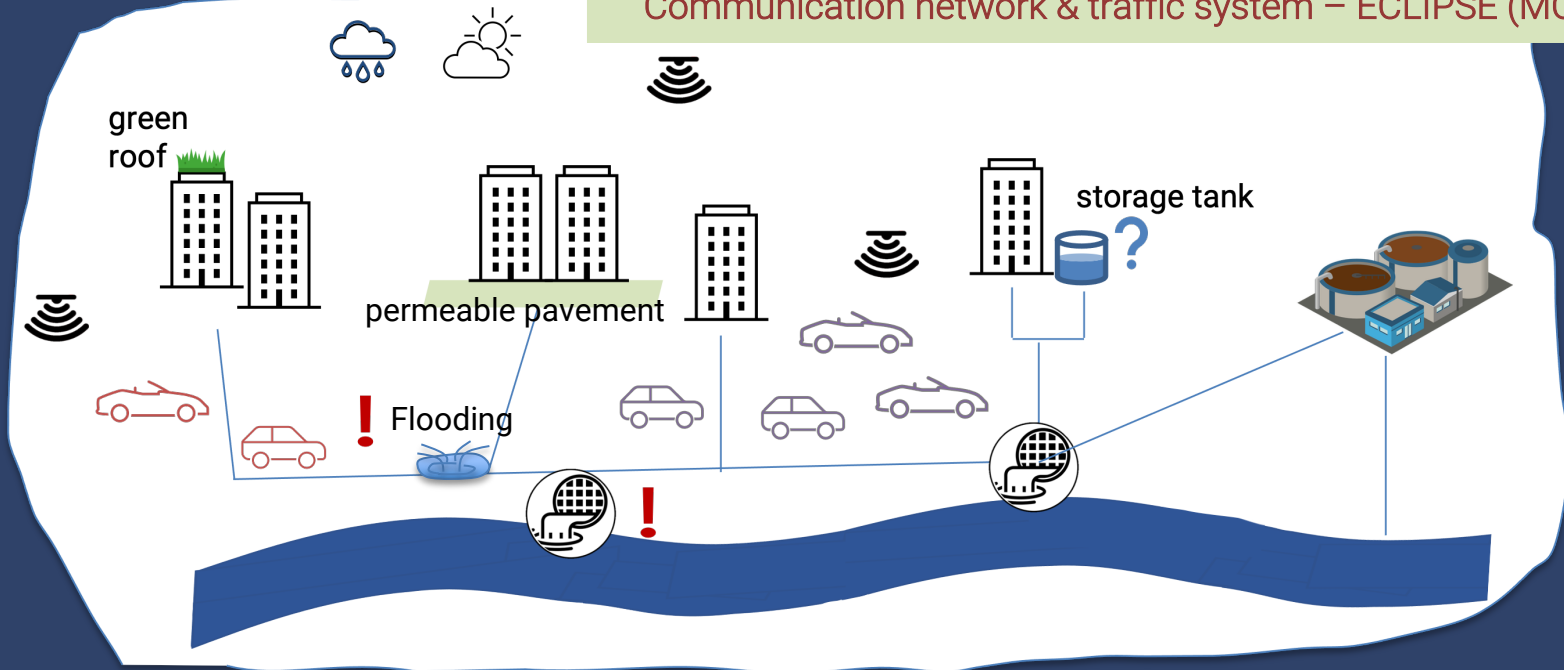


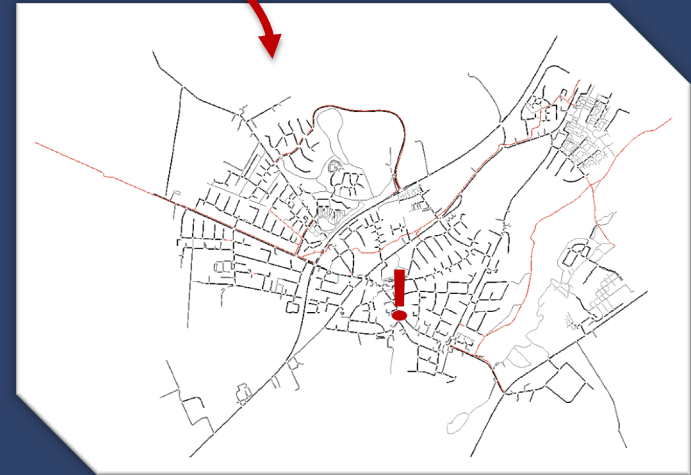
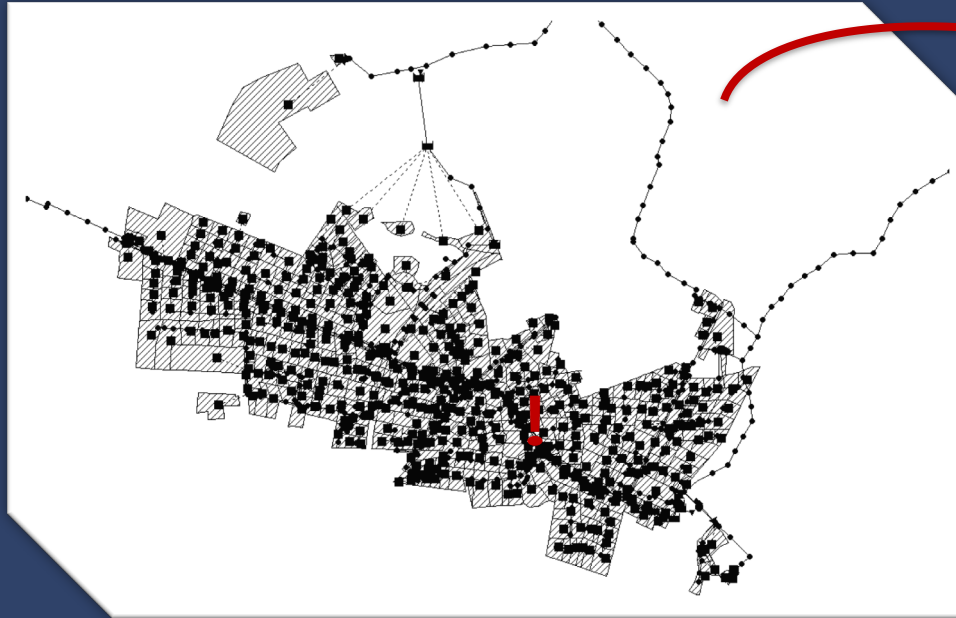
Icon of CSO from <https://www.blue-siren.com/collections/overflow-alarming>, WWTP from <https://pngio.com/images/png-a2274640.html>



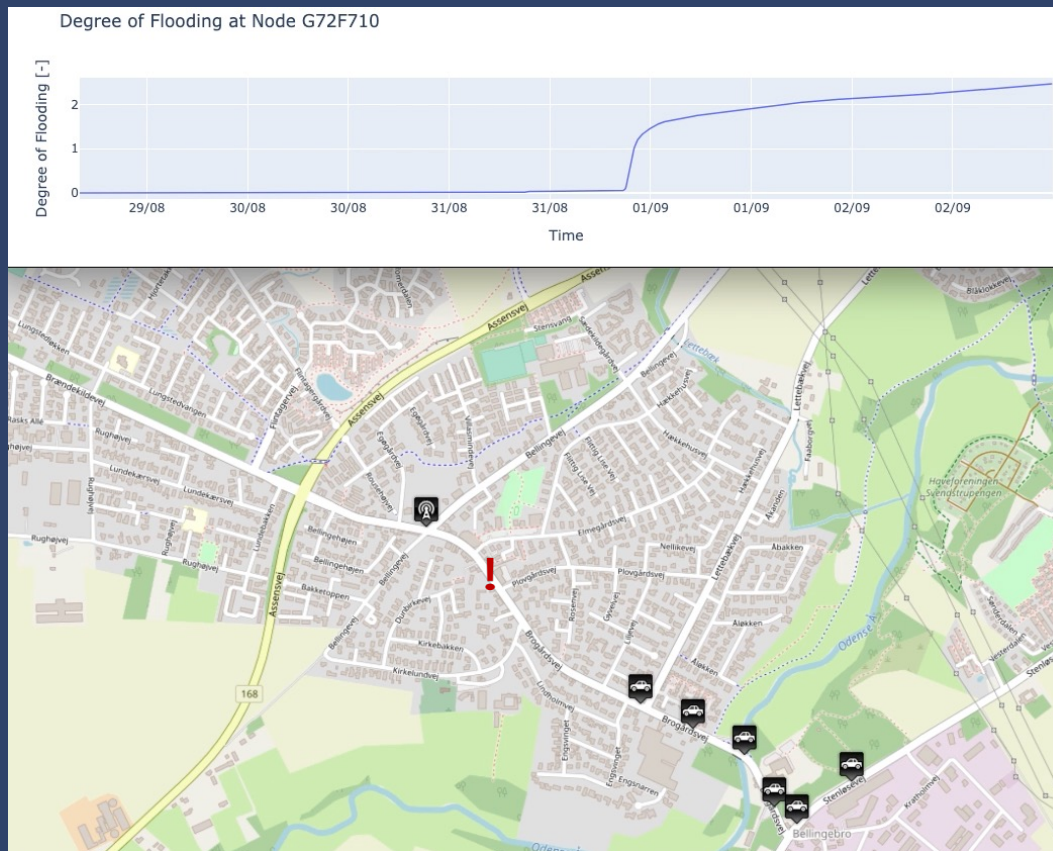
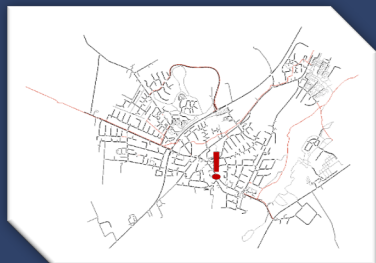
Stormwater (BGI, CSO, flooding) – SWMM<sup>1</sup>

Communication network & traffic system – ECLIPSE (MOSAIC)<sup>2</sup>



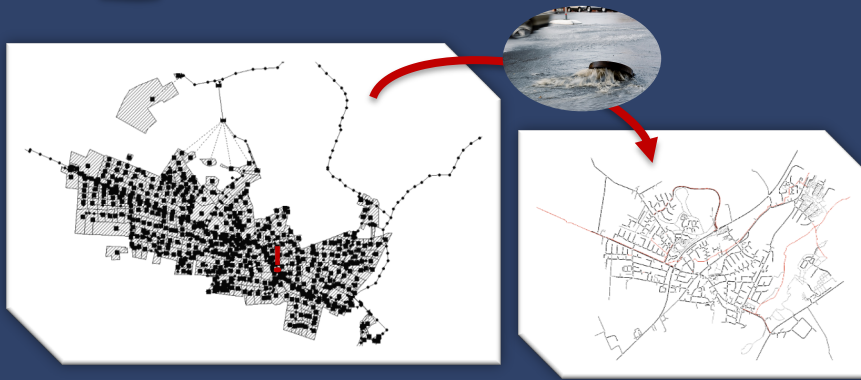


Source: Pedersen, A.N., Pedersen, J.W., Viguera-rodriguez, A., Brink, A., Borup, M., Mikkelsen, P.S., 2021. The Bellingue data set: open data and models for community-wide urban drainage systems research 1–28; <https://www.insblogs.com/catastrophe/frank-sewer-backup-basement-flooding/486>



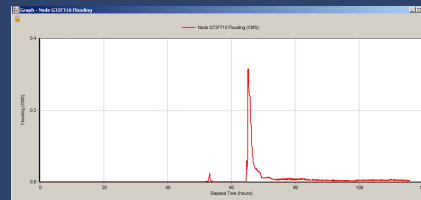


# Digital Campus & ConnectiCity



Workshops from the course **Critical Infrastructure and Digitalization**, 2021

- Stormwater management X Blue Green Infrastructure
- Avoiding hazardous traffic environments via V2X



**Smart City Hackathon**, 2021

- Challenge: couple street inundation models with SWMM

Source: Pedersen, A.N., Pedersen, J.W., Viguera-rodriguez, A., Brink, A., Borup, M., Mikkelsen, P.S., 2021. The Bellinge data set: open data and models for community-wide urban drainage systems research 1–28. <https://www.insblogs.com/catastrophe/frank-sewer-backup-basement-flooding/486>, <https://www.epa.gov/water-research/storm-water-management-model-swmm>



## “Critical Infrastructure and Digitalization”, summer 2021

Digital Water Networks and Interconnected Urban Infrastructure

– Prof. A. Cominola<sup>1,2</sup>

Future Pumping Stations

– Prof. P. U. Thamsen<sup>1</sup>

Modern Leakage and Erosion Monitoring

– Prof. K. Radzicki<sup>3</sup>

Digital Water City Project

– Dr. H. Schwarzmüller<sup>4</sup>



Digitalization of Urban Energy Systems

– Prof. R. Streblow<sup>1</sup>

Peer-To-Peer Energy Communities

– Dr. L. Ableitner<sup>5</sup>



Smart Energy Management of Electric Vehicles

– Prof. S. Park<sup>1,2</sup>

Decentralized Optimization of Intelligent Transportation Systems

– Prof. M. Liu<sup>6</sup>

Continuously Testing IoT Systems

– Dr. L. Thamsen<sup>1</sup> and J. Beilharz<sup>7</sup>

NebulaStream: IoT Stream Processing

– Dr. S. Zeuch<sup>1</sup>

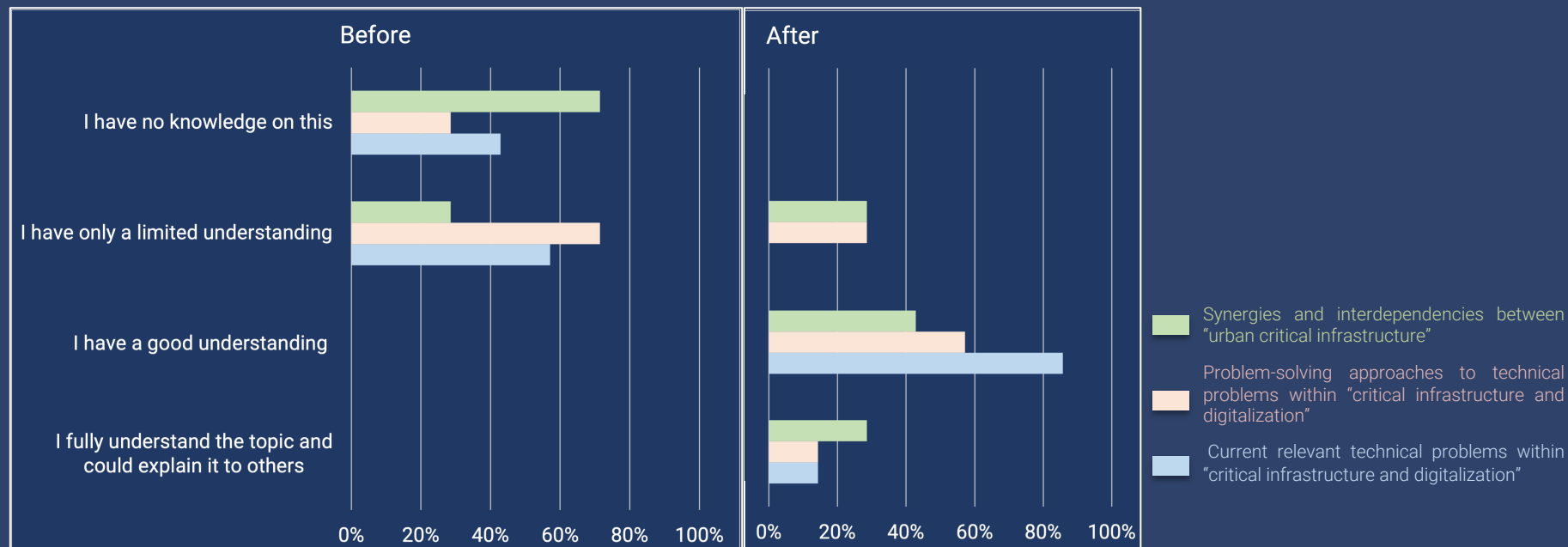
Social Media for Understanding City Dynamics

– Prof. M. Brambilla<sup>8</sup>



# Digital Campus – Achievements

Survey results from pre and post participation of the course "Critical Infrastructure and Digitalization", 2021



# Digital Campus – Achievements



- ✓ 3 new courses + 2 hackathons
- ✓ ~160 students attending the ide3a courses (3 semesters)
- ✓ 12 scholarships awarded (first edition)
- ✓ NEW partnerships established



"I value this experience deeply, and I am hoping for the success of the ide3a team and the other scholars in their futures."

- Carlos Muli (DCU student)







# ide<sub>3</sub>a

international alliance  
for digital **e-learning**,  
**e-mobility** and **e-research**  
in academia



## Envision



## Challenges

WHICH learning formats? (digital/blended/classroom)

HOW TO measure effectiveness of research-based learning?

WHAT are the lessons learned in providing effective training programs to students with very heterogeneous backgrounds?



# Thank You

ide<sub>3</sub>a



@Ide3a1

[www.ide3a.net](http://www.ide3a.net)

Siling Chen and the ide<sub>3</sub>a Consortium

[siling.chen@tu-berlin.de](mailto:siling.chen@tu-berlin.de)

DAAD

Deutscher Akademischer Austauschdienst  
German Academic Exchange Service



Federal Ministry  
of Education  
and Research