TUM: Junge Akademie

Research Reports #class24

What makes us human?

TUM: Junge Akademie

Research Reports #class24

Partner of

TUM Universitätsstiftung

Freunde der TUM Association of Alumni and Friends

EuroTeQ Engineering University

Dear friends of TUM: *Junge Akademie,*

The #class24 of TUMJA was a year full of energy, creativity, depth, and inspiration. The five research projects you will learn about in this year's book impressively demonstrate what is possible when young people – with openness, curiosity, and commitment – work together to explore pressing topics by handling open and challenging questions. Over twenty months, 34 students from seven TUM schools and 14 countries tackled complex questions about the future in addition to their duties in their studies, jobs, and other commitments. Their inter- and transdisciplinary collaboration proves that science and the pooling of scientific expertise to find solutions thrive on exchange, openness, shared imagination, and the integration of different perspectives and skills.

On 5 June 2025, the results of the projects were presented to TUM and the public at a symposium at TUM that was remarkable for its variety of ideas, impulses, and inspirations – the participants resonated with the presented projects and their results. The projects stand for the excellence and innovative spirit of our university and also for the values of TUMJA – freedom of thought, enjoyment of cross-disciplinary and intercultural discourse, a desire for responsibility, and a genuine passion for knowledge.

This year's motto “What makes us human?” came from the scholarship holders themselves – a powerful impulse that shows how contemporary and reflective our young talents are in their view of the world. TUMJA offers a space where enthusiasm, creativity, and personal responsibility can flourish, without any external incentives such as grades or financial scholarships. The decisive factor is inner motivation and the experience of genuine resonance in exchange with their team and with experienced scientists who contribute their empathy and commitment as tutors and supervisors. I want to express my special thanks to them. This voluntary work is anything but a matter of course – and yet it is so effective: it gives young people an experience that shapes them – and stays with them.

It was also an eventful and successful year for the TUMJA team, and I would also like to express my thanks to Peter Finger and his colleagues for continuing to scale up several projects and ideas that benefit a lot from the insights we have obtained in our work at TUMJA.

With the integration of TUM's EuroTeQ Collider, TUMJA's challenge-based learning has been part of a European network since 2024. Nine leading universities are collaborating on this initiative. Three teams from the original 16 participating teams will soon compete in the international competition at TU/Eindhoven, and another will represent TUM at the boot camp in Barcelona at the end of July. This is excellence in action – as well as European spirit in action.

The enthusiasm of TUMJA is also evident in its commitment beyond the research program and challenge-based learning. Some examples: The 11th TUM Campus Run was organized by the office with the help of over 60 volunteers, with a new participation record of 2,500 runners. And the TUM Science Hack, an idea from #TUMJA in 2018 and organized by the CAP task force, also exceeded all expectations with over 220 registrations. At the legendary dragon boat race on the Olympic Lake, the #class24 scholarship holders won first prize for creativity and finished third overall as “TUMJA in Wonderland.”

There are many more stories to discover, so let's look back on this year together, full of inspiration with and for our young talents and with anticipation for what is to come. I am sure that we will see many of the faces from #class24 again, not only as alumni but as shapers of our future – in academia, business, or politics, as people who never stop rethinking what is possible.

I hope you enjoy reading this project book, gain new insights, and continue to enrich the TUM and TUMJA network.

With warm regards,

Gerhard Müller
Senior Vice President Academic and Student Affairs

Dear TUM friends and associates,

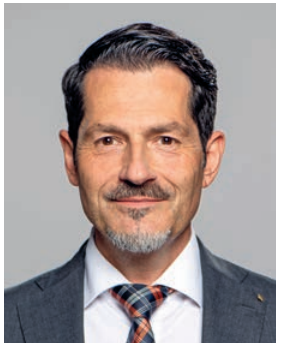
What defines us as human beings? This question – profound and timeless – stood at the heart of the #class24. It inspired five interdisciplinary teams of exceptionally talented students to explore complex, socially relevant topics with curiosity, rigor, and purpose. From science communication and assistive AI to moral argumentation, sustainable energy, and education research, their projects reflect a shared commitment: to understand the world not only as it is, but as it could be.

What makes these projects so compelling is not just their thematic range – it is their impact. Team communicaTUM investigated how tone influences the public's perception of genetically modified food, offering valuable insights for more effective science communication. insEYEght tackled the optimization of near-field AI systems to better support people with visual impairments. MEiNunG developed a novel analytical tool to identify moral perspectives in public discourse, while Windfo explored how researchers can communicate complex topics like wind energy in short, authentic videos. Meanwhile, PRISMatrix delved into the root causes behind declining math scores in PISA 2022, mapping divergent perspectives from science, policy, and the classroom.

All of these efforts are driven by young researchers – critical minds with the courage to question, the imagination to innovate, and the dedication to make a difference. In this sense, the TUM: Junge Akademie is far more than a scholarship program. It is a platform that empowers students to take ownership of their ideas and carry them into the world. It is a space for learning, growing, and contributing – together.

This Research Report celebrates student-driven research and invites us to trust in the next generation. #class25 is underway, and #class26 is ready to ask the next big questions.

As President of TUM, I warmly thank all TUMJA scholarship holders, alumni, friends, and sponsors. Your curiosity, creativity, and commitment enrich our university and drive progress in science and society.



Yours sincerely,

Thomas F. Hofmann
President

“Have no fear of perfection;
you'll never reach it.”

Marie Curie


communication
Advanced conflict resolution
mutual enthusiasm
structured timeline of the event
we had fun :)

TUM: Junge Akademie
Passion for Science

The TUM: Junge Akademie aspires to promote young academics in an integrated manner. Using the 20-month duration of the program, the students and doctoral candidates plan and develop a self-chosen research project within an interdisciplinary team. Our scholarship holders aim to find solutions for social issues, enable creative innovations, and review these concerning their feasibility. Throughout this process, they get support from top-class researchers, who guide them from substantiating their project idea to concluding it as a report, providing expertise and mentorship. Various workshops accompany the project, such as scientific and journalistic writing or project management.

Not every project is a success; sometimes, the teams must modify their ideas along the way. That is also part of learning. However, numerous projects in recent years have been so successful that other institutions have adopted and continued the successful work.

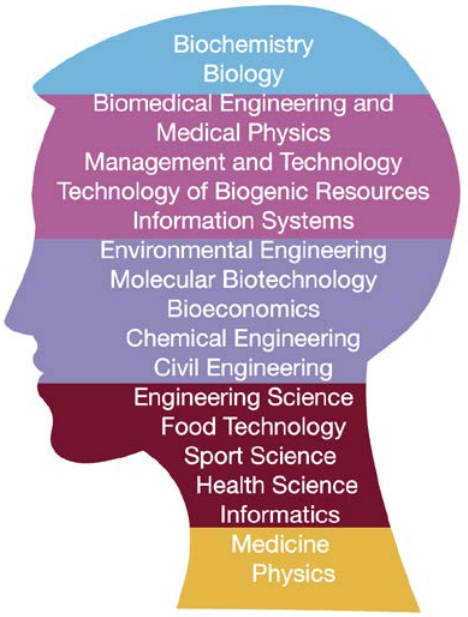
Aside from the project work, the TUMJA scholarship offers many opportunities for personal growth and development. The program includes an extensive supporting program with community-forging events, inspiring excursions, and more. What sets this program apart is that the scholarship holders essentially design it themselves, contribute their expertise to taskforces, and, by doing this, further develop their knowledge and personality.

We want to thank all members of #class24 for their commitment, dedication, and perseverance. We are proud to have you in the TUMJA community.

class 24 – Facts and Figures

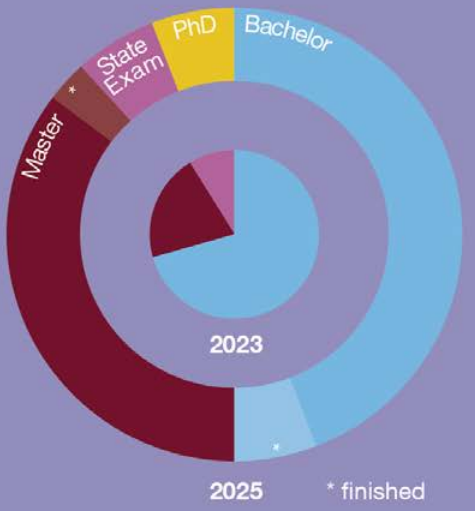
The exceptionally talented and committed scholarship holders and alumni of the TUM: Junge Akademie reflect a great diversity in many ways. Each class represents a wide range of social, cultural and, above all, academic currents at TUM.

The scholarship holders of #class24 study in 19 different fields of study.



34 students

During the scholarship, 7 scholarship holders finished their Bachelor's, from which 5 began a Master's. 3 scholarship holders finished their Master's or State Exam during the scholarship. To our great delight, 2 of them started a doctorate.



700+

68 active fellows and over 700 alumni, mentors, and professors from four universities are part of the TUMJA network. The community is characterized by the creativity of its members and their highly motivated personalities.

TUMJA class 2024

The scholarship holders of #class24 study at seven different TUM Schools.

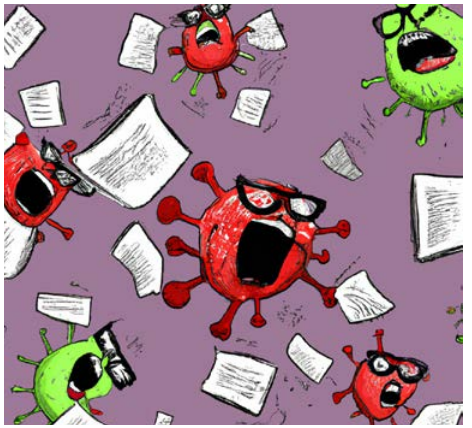
The diversity of the scholarship holders is also apparent in their origins, as the map illustrates. The different international influences enrich the interdisciplinary cooperation with important intercultural aspects.

19
different study programs

53%
female scholarship holders

15
nationalities

Impact – News from our Network



Research of team VINFO of #class22 has been published

The article Decoding the Discourse: Analyzing the Linguistic Features and Strategies Behind the Querdenken Movement's COVID-19 Narrative was published in Health Communication in March 2025.

"I'm incredibly proud of this interdisciplinary work, made possible by our fantastic team and the support of TUM: Junge Akademie. Our findings highlight the need to move beyond simple misinformation labels and instead understand the mechanisms through which alternative media construct credibility!" stated team member Alexander Sobieska.

Congrats to the whole team – Pia Gutsmiedl, Max Hampel, Seong-Min Jun, Cheng Pan, Valentin Pauli, Alexander Sobieska, and Rosa Weidenspointner – as well as their tutors, Junianna Zatsarnaja and Paul Sieber, and supervisors Dr. Kristina Schick and Prof. Dr. Eleni Georganta!

Find the full article on www.tandfonline.com

Read more about the project on www.ja.tum.de

Alumni presented

Dr. Martin Rothbucher
COO at KINEXON Industries
in an interview with Lucia Arens
and Joshua Fehn

Martin Rothbucher is an alumnus of the predecessor program of TUMJA – "Erfahrene Wege in die Forschung" – and has been a dedicated tutor and member of the TUMJA Advisory Board. After an apprenticeship in communication electronics, Martin studied teaching at vocational schools at TUM, specializing in electrical engineering and mathematics. After his studies, he earned his doctorate in electrical engineering at the TUM Chair of Data Processing. Martin currently works as COO at Kinexon.

In the interview, he gives an exciting insight into his career and the role TUMJA has played in it.

"As an apprentice, I was always impressed by the tasks that the engineers in the company have. However, I first had to return to school to catch up on my university entrance qualification because I only had a secondary school certificate. I then decided to study to become a teacher at vocational schools because it's a great mix: electrical engineering, engineering, mathematics, and some psychology and education, in other words, soft skills. The discussion groups, as part of the EWF program, dealt with the question: What about after graduation? Business? A doctorate? I was enthusiastic about the possibilities of what you can experience, research, and learn in a doctoral program."

Read the full interview with Martin Rothbucher on www.ja.tum.de

Dr. Karin Höglmeier
Bavarian Ministry of Agriculture
in an interview with Lucia Arens
and Marius Prock

Our scholarship holders Lucia and Marius spoke with Karin Höglmeier, who is currently heading a department at the Bavarian Ministry of Agriculture.

Karin Högelmeier's journey includes a notable connection to TUMJA, where she has been both a scholarship holder and a tutor. The interview delves into her career, her motivations for choosing forestry, and the impact of her experiences with TUMJA on her professional development.

"In my day-to-day work, it is certainly a challenge to bring together the thematic diversity in my department in order to create performance and team spirit. If you take a broader view, it is a great challenge to convey to society the importance of the forest for all of us. The forest is an ecosystem, a habitat, a filter system for fresh air, and, at the same time, a CO_2 sink. I think the understanding of this is sometimes lost – or sometimes not even there yet. One of the aims of the forestry administration is to bring the forest closer to the people. We see this as a cross-sectional task, and I play my part in this."

Read the full interview with Karin Höglmeier on www.ja.tum.de

Prof. Dr. Marcel Dann
TU Darmstadt
in an interview with Christina Schwalm and Vicente Algaba Martinez

Marcel Dann studied biology at TUM and is a TUMJA alumnus of #class13. He was part of the visiTUM team, a project adopted by the TUM's student advisory service and still ongoing today. Since 2023, he has been a professor at the Technical University Darmstadt. In the interview, he gives an exciting insight into his research topic and the highlights as well as the challenges of a scientific career.

"I first became interested in synthetic biology during my doctoral thesis. My supervisor in Munich at LMU put me on a synthetic biology project that dealt with the restructuring and redesign of plant photosynthesis using bacterial model systems. You quickly get a kind of Stockholm syndrome in science: what you're working on becomes more and more interesting because you spend so much time on it. If you have a general interest in the subject matter, then you end up being enthusiastic about what you are doing because everything can be endlessly interesting, depending on how you work on the topic."

Read the full interview with Marcel Dann on www.ja.tum.de

The Boards of the TUM: Junge Akademie

Advisory Board

Since the academy's founding in 2010, the Advisory Board has been the decision-making body for the TUM: Junge Akademie. The members convene twice yearly to discuss and decide on medium- to long-term strategic and organizational matters. Through their efforts, the Advisory Board members contribute to the academy's sustainable growth and high effectiveness.

Prof. Gerhard Müller, TUM Senior Vice President and Director of TUMJA, chairs the board. Six active and former scholarship holders represent the Board of Members. Six further members of the board are professors from TUM and the TUM Senior Excellence Faculty, as well as the TUMJA partner universities. Prof. Bettina Reitz, President of the Munich University of Television and Film, has been a member since 2017. In 2022, the President of the Munich University of Music and Performing Arts, Prof. Lydia Grün, became a member. Prof. Karen Pontoppidan, President of the Academy of Fine Arts Munich, joined in 2023. ■

Director:
Prof. Dr.-Ing. Gerhard Müller,
Senior Vice President Academic and Student Affairs

Scholarship Representatives:
Altan Birler
Monica Déchène
Eric Jacob
Stefan Lehner
Magalie Ross
Paul Sieber

Professors:
Prof. Dr. med. Pascal Berberat,
TUM School of Medicine
Prof. Dr. Sonja Berensmeier,
TUM School of Engineering and Design
Prof. Lydia Grün,
University of Music and Performing Arts Munich
Prof. Dr. med. (em.) Michael Molls,
Spokesperson Emeriti of Excellence
Prof. Karen Pontoppidan,
Academy of Fine Arts Munich
Prof. Bettina Reitz,
University of Television and Film Munich

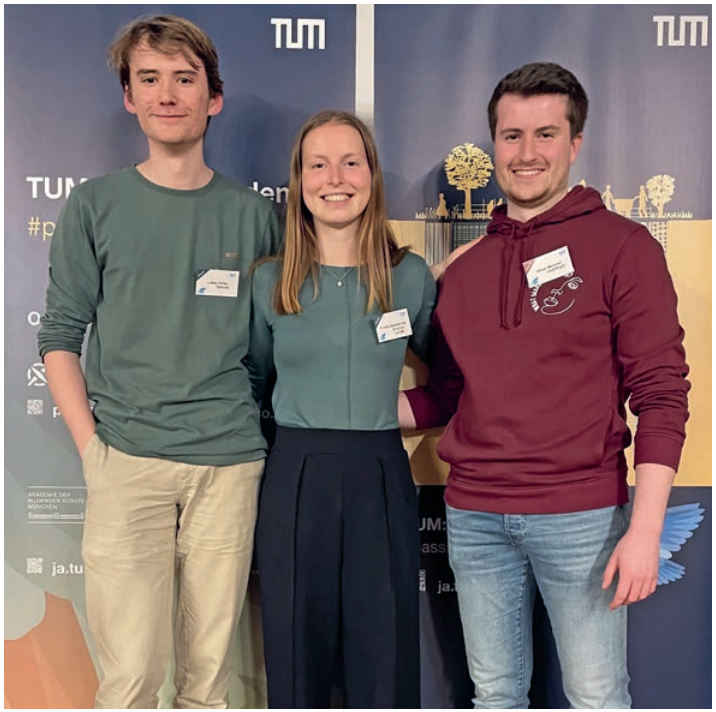
Board of Members

The Board of Members (BoM) represents the interests of all scholars, shapes ideas for the future of TUMJA, and serves as a bridge between various departments and groups – including taskforces, project teams, the office, trainers, supervisors, and professors. It also helps to answer questions or direct them to the right contacts.

The BoM elects six student representatives to join the Advisory Board, ensuring that scholarship holders are actively involved in decision-making. Proposals for changes to the scholarship program are discussed with the Advisory Board, the director, and the office team. Once an agreement is reached, fellows are encouraged to work with the BoM to put these decisions into action.

An important task of the Board of Members is to propose a call for the next class. This year, seven scholarship holders came up with seven initial ideas. These were thoughtfully discussed and combined into a main proposal for the Advisory Board: *Mind the Gap*. The gap between rich and poor, the research gap, the gender pay gap, gaps of accessibility in public transport, language barriers, and gaps … all these specific project topics were ideas by scholarship holders when brainstorming about the proposal *Mind the Gap*.

The Heads of the BoM also set up a WhatsApp community to improve communication among scholarship holders. The groups are used not only for announcements, but also for daily questions, discussions, and networking. ■



From left to right: Lukas Hörter, Franka Spitczok von Brisinski, Oliver Meixner

Meeting of the Board of Members at the Seminar Weekend in Burg Schwaneck in April 2025

TUMJA Office

The TUMJA office team plays a crucial role in supporting its scholarship holders in all stages of their projects, from planning and organizing to implementation and evaluation. The support provided is highly versatile and tailored to the needs of each team. Where one team needs technological support, another team might need the right people to get in touch with. One of the key focuses of the office is fostering networking and collaboration among all members. The TUMJA premises are available for teams to hold meetings and collaborate, offering a space to connect both during and after discussions.

In addition to supporting scholarship holders, TUMJA management serves as a point of contact for internal and external TUM partners. The office maintains close relationships with partners such as the TUM Universitätsstiftung and industrial partners Pixida and QuantCo, as well as the partner universities in Munich.

The office also handles a variety of essential tasks, including administrative and financial responsibilities. It plans, coordinates, and implements seminar weekends and workshops. Moreover, TUMJA hosts several high-profile events, such as academy talks, fireside chats with the TUM Graduate School, the TUM Science Hackathon, and the annual TUM campus run. Since 2023, TUMJA has been involved in the EuroTeQ Collider project.

Here is a brief introduction to the people behind these activities:

- Professor Gerhard Müller is the director of TUMJA and the head of the advisory board
- Peter Finger, the Managing Director, has been driving innovation and improvements for TUMJA since 2012.
- Angela Wester and Diane Baumer act as EuroTeQ Collider Manager.
- Dennis Lehmann oversees administration and general operations.
- Constanze Kukula is in charge of public relations.
- Student assistants Anna Forster, Ning Shuang Chiam, Alicia Baum, and Désirée Toepffer provide valuable support to the office throughout the year.

Faces

Scholarship Holders 2024

Verena **Aures**
communicaTUM
Physics (Nuclear, Particle and Astrophysics)

The seemingly endless number of unanswered questions is what keeps me curious and inquisitive. Science and research are essential for continuously advancing the world and making it a better place.

Debora **Baumann**
Windfo
PhD, TUM School of Engineering and Design

I enjoy the rewarding feeling of understanding a process through research driven by curiosity, creativity, and planning.

Martina **Casas Infante**
Windfo
Environmental Engineering

I loved sitting down for a coffee with all the new, insightful, interesting and kind people I met, and talk, laugh and learn together.

Chiara **Deleu**
InsEYEght
Chemical Engineering

What motivates me to do research is the opportunity to explore the unknown, satisfy my curiosity, and contribute to solving meaningful problems.

Vicente Mario
Algaba Martínez
communicaTUM
Health Science

One of my most memorable TUMJA moments was the research trip to Ghana. Also, the manyfold participation of communicaTUM in several fairs such as the Sustainability Day were very cool for me!

Lucia **Arens**
PRISMatrix
Mathematics

My best TUMJA moments were the seminar weekends. Meeting the other scholarship holders, having interesting discussions and hearing about the other projects was an exciting experience!

Maja **Benning**
communicaTUM
Physics (Nuclear, Particle and Astrophysics)

My favorite moment was at the end of a seminar weekend. My team, communicaTUM, spent the entire time discussing our SMART goal. By Sunday, I knew that our team would work exceptionally well together.

Maria Camila
Bustos Vivas
Windfo
Biomedical Engineering and Medical Physics

One of the highlights of my TUMJA journey was gaining hands-on experience in media production and conducting street surveys. These skills expanded my perspective and enriched my personal and academic development.

Bushra **Demyati**
PRISMatrix
Civil Engineering

My best TUMJA moment: Enjoying good food, drinks, and games with the other scholarship holders after long seminars. We even got to splash around in a nearby lake. It was freezing cold, but so worth it!

Konstanze Maria
Dietlmaier
PRISMatrix
Management

TUMJA consists of many sincere and open-minded people, who love to have deep, thoughtful, and sometimes funny discussions. I feel inspired by them.

Joshua **Fehn**
InsEYEght
Information Systems + Engineering Science

My motivation for Science and Research? Nothing less than to better understand the universe ;)

Maximilian Josef **Frank**
MEiNunG
Information Systems

Conducting research is not only about solving problems. It is about advancing society by generating knowledge. Sharing it is free and comes with exponential effects. For me, science is passion.

Elke **Haldmaier**
PRISMatrix
Sports Science

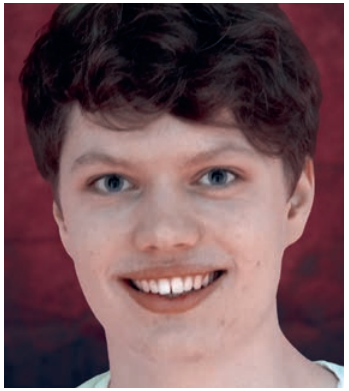
My motivation for science and research: I'm curious to explore and to share knowledge that empowers others to make informed decisions.

Maximilian **Hillgärtner**
InsEYEght
Sports Science

Getting to know the other sholarship holders was one of the best parts of TUMJA.

Maximilian **Kellner**
InsEYEght
Bioeconomics

TUMJA gave me a lot of orientation, showing me which work tasks I enjoy. This was enabled by a setting that I haven't experienced before; neither in my academic nor my professional career.



Tim **Knothe**
MEiNunG
Informatics

The best TUMJA moment was when we were all still sitting together in the evening at Schwaneck castle, long after the actual end, and talking about life.

Samuel Clemens **Friese**
InsEYEght
Physics

A highlight for me were always the seminar weekends – connecting with people from other teams and enjoying the relaxed evening atmosphere.

Nicole **Fritsch**
Windfo
Human Factors Engineering

The TUMJA scholarship program showed me the ups and downs of scientific work within an interdisciplinary team and a supportive environment. It encouraged me to consider a scientific career.

Eric **Jacob**
Windfo
Informatics

The scholarship gave me the opportunity to "do science" in a much more hands-on manner than my studies could, while also making my upcoming Bachelor's thesis seem a lot less scary and more manageable.

Olivia **Jarosch**
communicaTUM
Biology

My interactions with students in Ghana have made me realize that the perception of science communication is often shaped by local realities, cultural contexts and everyday challenges.

Nicolas Ian **Lugger**
communicaTUM
Biology

The TUMJA program is a great way to connect with peers and find new avenues through life. I made one of my closest friends ever here, and I would not miss that.

Julius **Mankau**
MEiNunG
Management and Technology

I have always liked to ask the question ”why“. At some point, you have to get the answers yourself.

Oliver **Meixner**
InsEYEght
Physics (Applied and Engineering Physics)

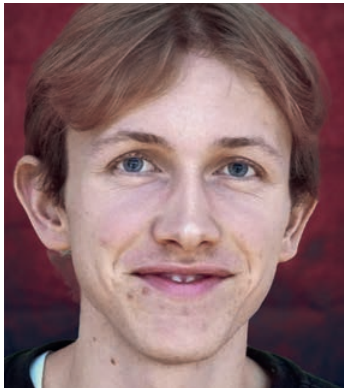
I loved the weekends where we could exchange ideas and push the project forward at a pace I had never imagined. Everyone was motivated and genuinely eager to make a difference.

Praissya **Nathania**
PRISMatrix
Food Technology

With no prior research experience, TUMJA offered key insights into scientific work. Collaborating across disciplines and cultures broadened my knowledge and reshaped how I view the world.

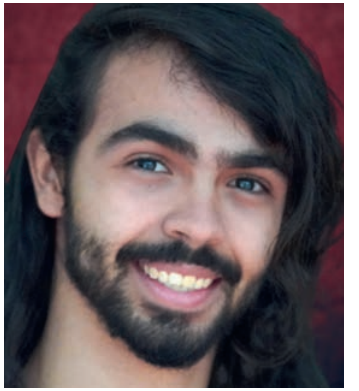
Marius **Prock**
PRISMatrix
Mathematics

I absolutely enjoyed every weekend, where we could talk about everything with like-minded people, from science to sports and politics.



Omar **Rashed**
communicaTUM
Molecular Biotechnology

Science is not just a process, it is a story capable of ushering in either great ease or hardship, depending on how it is led. Its potential to educate and help others is what enchants me.



Abhirami **Sreeprakash**
PRISMatrix
Technology of Biogenic Resources

TUMJA gave me countless great moments – from seminar weekends to team talks. My favorite was the first weekend, meeting fellow scholars, sharing laughs, and enjoying our first party night.

Nikola **Staykov**
MEiNunG
Engineering Science

TUMJA has allowed me to meet and collaborate with passionate, hopeful, and energetic people. I have gained a lot from the experiences.

Christian **Nix**
MEiNunG
Informatics

I am a very curious person, and science is a tool to answer my questions. And because there are still questions without answers, I want to try to answer them.

Viktoria **Obermeier**
MEiNunG
PhD, TUM School of Medicine and Health

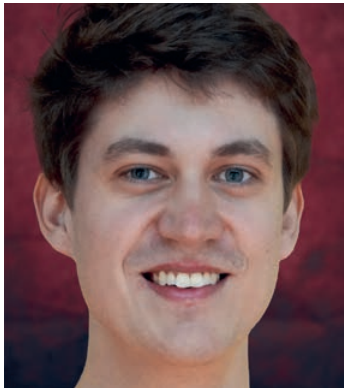
TUMJA showed me that there is more to explore beyond my own field of study and inspired me to dream big, especially as a woman in science.

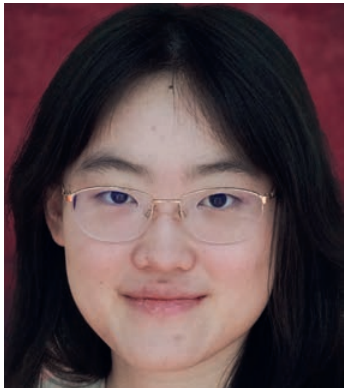
Liza **Saneblidze**
InsEYEght
Biology

My passion for research is driven by my aspiration to positively impact the lives of others. I am grateful to say that this goal also became the main principle for our team's project.

Max **Schultz**
InsEYEght
Biochemistry

To me, science is like going for a run. It's hard along the way, but it's pure joy whenever you reach a goal.





Yunqing **Wang**
MEiNunG
Finance and
Information Management

Out of curiosity, I want to systematically explain things I haven't fully understood until now. The world is full of mysteries, but at the very least, we can try to grasp some insights using our humble models.

Annemarie **Weibel**
Windfo
Medicine

My motivation is to get a better insight into the nature of science. Research stands for progress and development. Scientific Research enables a deeper understanding of the world we're surrounded by.

Tutors

Monica **Déchène**
InsEYEght
TUM CIT / Ph.D. student

Providing my own TUMJA insights to Team InsEYEght and watching their ideas grow into impactful visions has been an inspiring and fulfilling experience.

Stefan **Engels**
MEiNunG
TUM CIT / Ph.D. Student

Mentoring team meinung felt like supervising a thesis, offering guidance when needed, and observing the development of a remarkable project. This is truly inspiring and allowed me to reflect on my past TUMJA project.

Andrea **Schittenhelm**
PRISMatrix
Freelance Author

Mentoring is not a one-way street. The mutual exchange of knowledge inspires the project teams to think outside the box and broadens the mentor's perspective to embrace the specifics of a wide range of research areas.

Eva-Madeleine **Schmidt**
MEiNunG
Max Planck School of Cognition/
Ph.d. Student

I enjoyed offering impulses and supporting the team, and I learned just as much from them. It was a great reminder of how much creative energy and insight can come from working across different perspectives.

Altan **Birler**
PRISMatrix
TUM CIT / Ph.D. Student

My best TUMJA moment: Distracting my team with fresh mandarins while they were trying to concentrate on their task.

Andrei **Costinescu**
Windfo
TUM CIT / Ph.D. Student

I am very proud of windfo for the impact that the project will have on science communicators. The team has done a great job and I'm very happy to have been involved in supporting their journey.

Mohamed Zied **Jaber**
communicaTUM
Max Planck Institute
of Quantum Optics

Seeing the team make it to Ghana was the highlight of the project. It epitomises what TUMJA is about: exchanging with great people across all fields, disciplines and cultures!

Alesia **Prendi**
Windfo
h4a Architekten

It was a rewarding experience to see the team develop a thoughtful project, reflecting a growing awareness of the importance of science accessibility in the age of social media.

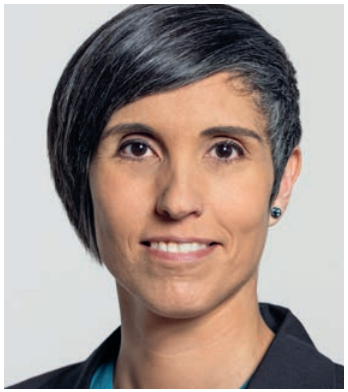
Christina **Schwalm**
communicaTUM
Büscher Architekten

What stayed with me most was seeing my team build connections in Munich and Kumasi. Just as unforgettable: the monkeys that broke into our room and tried to eat my passport. I'm grateful for this journey with them!

Martin **Zirngibl**
InsEYEght
LMU / Ph.D. Student

The best TUMJA moments for me are witnessing the scientific and character development of my team over the course of their time in TUMJA.

Supervisors



Prof. Dr. Gisela **Detrell**
Windfo
TUM School of
Engineering and Design

During my career, I have often experienced that the most valuable ideas came from interdisciplinary teamwork. I encourage young researchers to stay open-minded and collaborate beyond the boundaries of their specific fields.

Prof. Dr. Claudia **Klüppelberg**
MEiNunG
TUM Senior Excellence Faculty

As supervisors, we had the privilege of observing a team of young students developing from highly motivated singletons in different study programs into a joint research team.

Prof. Dr. Johannes **Betz**
InsEYEght
TUM School
of Engineering and Design

One of my favorite TUMJA moments was witnessing a team's initial concept evolve into a real idea and solution through collaboration and shared passion. That transformation – from idea to impact – never gets old.

Prof. Dr.-Ing. habil. Richard **Bamler**
communicaTUM
TUM Senior Excellence Faculty

My best TUMJA moment was when I heard that "my" team's application for funding for a trip to KNUST in Ghana was approved.

Prof. Dr. Martin **Werner**
MEiNunG
TUM School of
Engineering and Design

Beyond the technical achievements, what stood out most was the spirit of cooperation and the common goal within the team.

Prof. Dr. Jörg **Niewöhner**
PRISMatrix
TUM School of Social Sciences
and Technology

I sincerely thank the team for having the courage to explore territory unknown to them conceptually, methodologically, and disciplinary. They stuck with it and did not lose sight of their goals. Well done to all of you!

Dr. Bernhard **Isopp**
communicaTUM
TUM School of Social Sciences
and Technology

The team recruited me because my methodological competencies involve qualitative methods. By the end of the project, I learned a lot about statistics from them. The teacher-student relationship always goes both ways!

Projects 2024

Research Report **communicaTUM**

The communicaTUM project explored how tone and format shape public perceptions of genetically modified foods in the context of food security. In Germany and Ghana, participants were shown either humorous/inspirational or contemptuous/dramatic stories about genetically modified bananas, via text or video. Surveys measured emotions, attitude shifts, and political engagement. We gained promising results for social psychology and science communication, encouraging more reciprocal dialogue between communicators and the public. These findings are a first step toward broader research on reaching especially young adults with globally relevant, anxiety-inducing topics.

Team	Maja Benning Nicolas Ian Lugger Olivia Jarosch Omar Rashed Verena Aures Vicente Algaba Martinez
Tutors	Christina Schwalm Mohamed Zied Jaber
Supervisor	Prof. Dr. Richard Bamler Dr. Bernhard Isopp

Preface by the Supervisor

Prof. Dr. Richard Bamler and Dr. Bernhard Isopp

With the rise of populist political forces, evidence- and science-based political decision-making in Germany and other European democracies has come under pressure. Scientific findings are quickly dismissed as fake news if they don't fit in with one's own worldview. This makes effective science communication all the more important, and it was the reason why I chose to become a supervisor for the communicaTUM project. First, we had to decide on a topic for which the effectiveness of different communication means had to be investigated. We excluded the most obvious topic, “climate change,” because it has already been discussed to death in the public. “Food security and GMOs” seemed to be a better choice in this aspect. As a methodological means, surveys were used to show how much the participants’ opinions about GMOs have changed or were confirmed, depending on whether they read a factual or humorous text or watched a factual or humorous video. The participant cohort comprised different age and education levels as well as national, cultural, and religious backgrounds. To be honest, it wasn't much of an effort for me to supervise the team as they worked very independently. It was a pleasure to accompany this dedicated group, and I am convinced they have the potential to become enthusiastic and successful scientists. I wish them all the best.

What was your best TUMJA moment?

My best TUMJA moment was when I heard that “my” team's application for funding for a trip to KNUST in Ghana was approved. There, they could enrich their surveys with a non-European cultural dimension. The trip was also an exciting personal experience that they will remember for a long time.

The communicaTUM team approached me to co-supervise this project with Prof. Dr. Bamler due to my work on science communication. Science communication is an exciting field because it is an area where science, technology, and society directly and visibly interact. As a research topic, it is challenging for the same reason: communication and the media are typically the purview of the social sciences, but assessing the complex and diverse ways scientific knowledge is communicated also requires a good understanding of science. What excited and impressed me about the team is how they chose their topic precisely because they wanted to take on this challenge. The team comes from natural science and engineering disciplines with relatively little background in the social sciences, but they recognized how crucial it is, as scientists, to understand how science and technology shape and are shaped by society. To this end, they developed a thoughtful and impressive project that does not imagine science to be reducible to some essential content, but rather acknowledges and examines how crucial different kinds of messaging and affect are for engagement with and understanding of science.

The Journey of communicaTUM

Exploring Science Communication Across Borders

In October 2023, a group of students came together to form communicaTUM with a shared goal: to contribute to the improvement of science communication. Our study revealed that the impact of tone and format varied notably between different participant groups. While “Nominal Participants” responded more strongly to the tone of the video, the “Interested” and “Strategic Delegators” were influenced by both the tone and the format. Across all groups, a contemptuous tone tended to provoke stronger feelings of anger. Nonetheless, some participant groups showed more pronounced, negative reactions to textual information rather than audiovisual one. These insights highlight the importance of tailoring science communication not only to the message but also to the audience it aims to reach.

Our inspiration stemmed from the ongoing anxiety about climate change, particularly among younger generations. The team aimed to explore how controversial topics could be communicated effectively, encouraging critical thinking and action without imposing a specific opinion. After extensive discussions, we decided to investigate how different tones of communication influence the perception of scientific information. Our chosen controversial subject was: genetically modified organisms. Given the increasing role of social media in shaping opinions, short videos were selected as the medium of choice.

Before launching the study, the team first had to produce the videos. We chose to focus the scripts on the Cavendish banana – crop that plays a central role in the genetic engineering debate. As a striking example of the fragility of monocultures, the Cavendish illustrates both the promise and the complexity of genetic modification. Two versions of the script were developed: one delivered in a serious tone, the other with a humorous twist. A voice actor brought both to life, accompanied by matching visuals. To assess the impact of tone on perception, the team also designed a survey that gathered demographic data and measured how participants’ views on GMOs shifted after watching the videos.

The first data collection took place in June 2024 at the Zamanand Festival. Excitement ran high as the team engaged with participants for the first time. Despite heavy rain leading to fewer visitors than expected, the thrill of seeing our project come to life and gathering initial data was immense. This was followed by participation in other events, such as the Sustainability Day in Garching, where insightful discussions on genetic engineering and science communication took place. A highlight of our journey was the visit to the DLR School Lab in Oberpfaffenhofen, facilitated by our supervisor, Professor Richard Bamler. Observing how aerospace science was communicated in an engaging and comprehensible way to young students was truly inspiring – an ideal model for science communication.

By the end of 2024, close to 600 German participants had taken part in the study. The team then contemplated expanding our research. Given the strong academic ties between TUM and KNUST (Kwame Nkrumah University of Science and Technology), and the precedent set by a previous group from #class23 traveling to Ghana, we saw an opportunity to extend our study there. Agriculture plays a significantly larger role in Ghana than in Germany, and climate change effects are more immediately felt. The team was curious to see how these factors might influence science communication.

With this mission in mind, part of the project team boarded a flight to Accra in mid-March. After a seven-hour bus ride from Accra, we arrived, exhausted but eager, in Kumasi at KNUST. The KNUST campus in Kumasi is spacious, green, and almost park-like, with many trees, botanical gardens, and a lively, open atmosphere. In contrast, the TUM campus in Garching feels more technical and compact, characterized by modern buildings, labs, and a more structured layout. While KNUST offers more nature and space, TUM focuses on high-tech infrastructure and specialized research facilities.

Our initial enthusiasm was met with a setback – the professor meant to supervise us had fallen ill, and a replacement had yet to be found. Despite this disappointment, we made the best of our unexpected free time, exploring the campus botanical gardens and the city of Kumasi. Over the weekend, we embarked on a trip to Mole National Park, where we were fortunate enough to witness elephants and antilopes in the wild. However, our adventure took an unexpected turn when we returned to our room to find that monkeys had ransacked it after we had mistakenly left the terrace door unlocked – an unforgettable lesson in wildlife awareness!

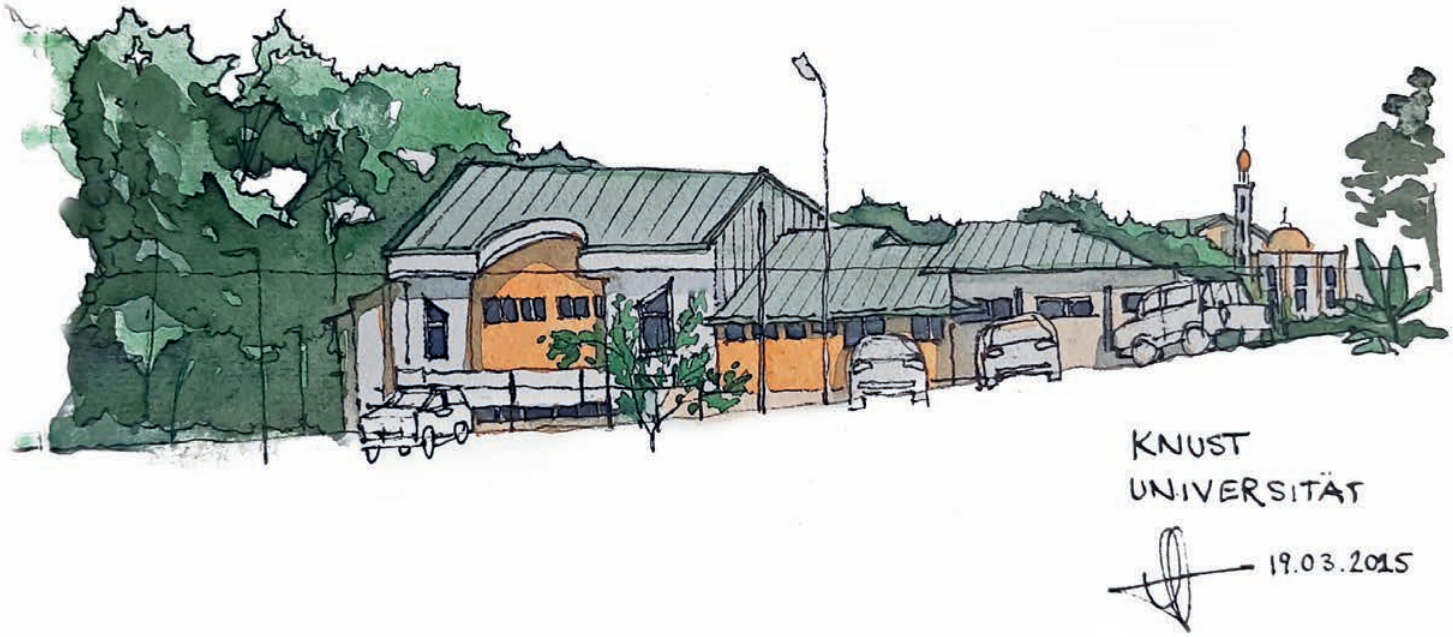
Upon returning to KNUST, we received exciting news: several professors had agreed to let us conduct our study in their lectures. We had the privilege of gathering study participants and attending lectures by Professor Philip Antwi-Agyei (Climate Change and Sustainability Science) and Professor Francis Appiah (Agricultural Science and Horticulture). The exchange with Ghanaian students proved to be invaluable. Many of them worked in the agricultural sector and had already engaged deeply with the topic of genetic engineering. They, too, were keenly interested in how such topics could be communicated effectively within their communities.

One particularly insightful conversation unfolded after a lecture by Professor Appiah. “Ghanaian farmers are often urged to use GMO seeds, which promise higher outputs. The land, however, is left with varying degrees of quality,” elucidated David, a master’s student with extensive experience in the agricultural sector. He continued, “A lot of communication between farmers and scientists will be needed to bring the dream of sustainable GMO farming to fruition.” His words reflected the complex balance between innovation and environmental responsibility in Ghana’s farming practices.

Another moment that stuck with the team was a simple yet powerful comment from a local taxi driver in Kumasi: “Ghana needs more farmers.” This statement echoed through many of the conversations our group had in the following days. It emphasized how central agriculture is to the country’s identity – and how crucial it is to include all voices in the discussion about its future, especially when it comes to controversial technologies like genetic modification.

By the end of our time in Kumasi, the team had collected data from over 120 participants. Before concluding our journey, we took the opportunity to explore Ghana further. In Kakum National Park, we marveled at the rainforest from treetop walkways and even spent a night in a treehouse. Our trip continued to Cape Coast, where we learned about Ghana’s history as a hub of the transatlantic slave trade – a sobering and educational experience. One key takeaway from our time in Ghana was the realization that science and science communication are deeply influenced by cultural contexts.

As our tenure at TUMJA ended, our team reflected on our achievements with pride. We had successfully conceptualized, designed, and conducted our own research project – one that spanned continents. Grateful for this opportunity and for all the lessons learned, we closed this chapter in our lives with a heartfelt “Thank you!” to everyone who has supported us along the way.



Research Report – communicaTUM

The impact of tonality on the acceptance of new technologies is dependent on culture, medium and sociodemographic factors

Table of contents:

Abstract

The communicaTUM project investigated how communication tonality and medium affect public perceptions of genetically modified foods within the context of food security. Participants in Germany and Ghana were exposed to either humorous and inspirational or contemptuous and dramatic versions of a story about genetically modified bananas, presented via text or video. Surveys assessed emotional responses, changes in attitudes toward GMOs, and willingness to take political action. Results showed that while dramatic communication elicited stronger emotions, text formats generally had a greater impact on attitude change than videos. Ghanaian participants exhibited higher engagement, greater concern about food insecurity, and more positive attitudes toward GMOs compared to their German counterparts. Cluster analyses revealed distinct engagement patterns within both populations, highlighting the significant influence of sociocultural context. This study underscores the importance of emotional tonality, communication medium, and cultural factors in shaping science communication effectiveness, particularly when addressing complex and controversial topics like genetic engineering.

Background

The inspiration for our project comes from the growing awareness that communicating scientific issues has a significant impact on public perception and mental well-being. A clear example of this is the shift in terminology from "global warming" to "climate change" since 1990 (Ellen Good, 2008). This change was necessary to give a more refined sense of the climate crisis, while reducing the sense of alarm associated with the term, aiming for a more neutral and comprehensive way to describe the phenomenon. However, even with these adjustments in language, the emotional and psychological effects of climate-related discussions remain substantial, particularly among younger generations (Majeed & Lee, 2017).

Research has shown that many young people experience "climate anxiety," a growing sense of distress, depression, and hopelessness about the future of the planet. A large-scale study surveying over 10,000 young individuals found that the majority feel worried about climate change, with many also frustrated by what they see

as insufficient action from governments (Hickman et al., 2021). This highlights the importance of carefully considering how we communicate complex scientific topics – not just to inform, but also to ensure that messaging does not contribute to fear and anxiety. Our project builds on these insights, exploring how communication strategies shape attitudes toward genetic modifications in food and food security.

Similar to the discourse surrounding climate change terminology, the term "genetic modifications" often evokes perceptions of risk and unnaturalness among the public. This negative connotation has led to resistance to the promotion of genetically modified organisms (GMOs), with concerns spanning health risks, environmental impact, and ethical considerations. For instance, a study on public attitudes in Wales highlighted that "the transfer of genes between different species is often criticized as “playing God” or breaking the “Law of Nature” (Mulready, 2017). Furthermore, research indicates that the terminology used significantly influences public acceptance; for example, terms like "bioengineering" are perceived more neutrally compared to "genetic modification," which carries more negative associations (Marcus & Velardi, 2023). These insights underscore the importance of mindful communication strategies in the field of genetic engineering to foster informed public discourse and acceptance.

Understanding and clarifying the impact of genetic modifications on food and public perception is crucial in today's global landscape. While Europe maintains a cautious stance on genetically modified (GM) foods, countries like the United States and China have embraced their integration into common food products. This divergence underscores the need for comprehensive public education and transparent communication regarding the benefits and risks associated with GM foods. Effective communication strategies can bridge the gap between scientific advancements and public understanding, fostering informed decision-making and acceptance.

The significance of directed genetic modifications cannot be overstated, as they represent one of the most pivotal technologies of the 21st century. Advancements such as CRISPR-Cas have revolutionized genetic research, offering precise and efficient tools for crop improvement and disease resistance (Redman et al., 2016). These technologies, while also bringing severe ethical considerations into account (Shinwari et al., 2018), hold the potential to address global challenges, including food security and environmental sustainability. As genetic modification techniques continue to evolve, their integration into various sectors is likely to expand, making it imperative to engage the public in meaningful dialogues about their applications and implications. Therefore, this study aims to examine how different communication tonalities (humorous & inspirational vs. contemptuous & dramatic) influence the way the general public processes news about genetically modified foods. By exploring the impact of tonality on audience perception, this research aims to contribute to the development of strategies for more effective science communication.

Genetic modifications refer to the deliberate alteration of an organism’s genetic material using biotechnology to achieve specific traits. This process can involve the insertion, deletion, or modification of genes to enhance characteristics such as pest resistance, drought tolerance, or nutritional value in crops. Techniques such as transgenesis, where genes from one species are introduced into another, and gene editing, which allows precise modifications without introducing foreign DNA, have significantly advanced agricultural biotechnology (Zhang et al., 2021). These innovations play a key role in modern food production, aiming to improve yield, reduce reliance on chemical pesticides, and contribute to global food security. Thus, genetic modifications have enabled targeted improvements that would be difficult to achieve through conventional breeding.

CRISPR-Cas9 is a groundbreaking gene-editing technology that allows scientists to make precise changes to DNA, the molecule that carries genetic information in living organisms. Originally discovered as a natural defense mechanism in bacteria, where it protects against viral infections, CRISPR-Cas9 has been adapted for use in various organisms, including humans, plants, and animals (Jinek et al., 2012). The system works by using a custom-designed

guide RNA (gRNA) that matches a specific DNA sequence targeted for editing. Once inside the cell, the gRNA directs the Cas9 enzyme to this exact location, where Cas9 acts as molecular scissors, cutting the DNA strand. The cell's natural repair mechanisms then attempt to fix the break, providing an opportunity for scientists to introduce specific genetic modifications, such as inserting or deleting DNA segments.

This technology has revolutionized genetic research and biotechnology due to its simplicity, efficiency, and versatility. It enables targeted modifications with unprecedented precision, facilitating advancements in medicine, agriculture, and basic science. CRISPR-Cas9 holds the potential to correct genetic mutations responsible for diseases, enhance crop resilience, and to study gene functions comprehensively. The development of this method is credited to Emmanuelle Charpentier and Jennifer Doudna, who were awarded the 2020 Nobel Prize in Chemistry for their pioneering work. Their research transformed CRISPR-Cas9 from a bacterial immune system into a versatile genome-editing tool, opening new frontiers in genetic engineering while also raising important ethical considerations (Ledford & Callaway, 2020).

Genetic modifications have led to significant advancements in both medicine and agriculture. In medicine, this has enabled the development of precise editing of defective genes responsible for various diseases, offering potential cures for genetic diseases such as sickle cell anaemia and certain cancers (Xu et al., 2024). In agriculture, genetic modifications have resulted in crops with enhanced properties, such as disease-resistances or higher nutritional profiles. A notable example is Golden Rice, engineered to produce beta-carotene, a precursor of vitamin A. This rice, developed by Ingo Potrykus and Peter Beyer, aims to address vitamin A deficiencies prevalent in some developing countries (Beyer et al., 2002).

Prior to the advent of modern genetic modification techniques, traditional breeding methods such as selective breeding and hybridization were employed to enhance desirable traits in plants and animals. In plant breeding, techniques like irradiation mutagenesis were utilized to induce genetic variability. This approach involved exposing seeds or plant tissues to ionizing radiation, such as gamma rays, to create mutations that could result in beneficial traits. However, this method often led to unintended genetic changes, raising concerns about potential health and environmental risks associated with the consumption and cultivation of such crops (Ma et al., 2021).

In animal husbandry, inbreeding—mating closely related individuals—was commonly practiced to reinforce specific traits within a population. While this approach could establish desirable characteristics, it also increased the likelihood of expressing deleterious recessive genes, leading to inbreeding depression. This phenomenon manifests as reduced fertility, lower growth rates, and increased susceptibility to diseases in livestock populations. Studies have documented the negative impacts of inbreeding on dairy cattle, highlighting declines in reproductive performance and overall fitness (Gutiérrez-Reinoso et al., 2022).

The challenges posed by traditional breeding methods, such as unintended mutations from irradiation in plants and genetic weaknesses from inbreeding in livestock highlight the need for more precise and sustainable approaches in agriculture. While these older techniques have shaped modern food production, they often come with significant risks and limitations. In contrast, genetic modification provides a targeted and efficient alternative, allowing for controlled improvements without the unpredictability of conventional methods. This innovation is particularly crucial in addressing current agricultural threats that could jeopardize global food security.

A striking example of this necessity is the crisis facing the Cavendish banana, the dominant variety in global markets, which is now under threat from *Fusarium oxysporum* f. sp. *Cubense* TR4 (Butler, 2013). This situation mirrors the mid-20th-century devastation of the Gros Michel banana, which was nearly wiped out by a similar fungal strain. Due to its genetic uniformity, the Cavendish is highly susceptible to TR4, making it vulnerable to the same fate. However, genetic modification offers a promising solution. A study published in *Nature Communications* demonstrated that introducing a resistance gene from a wild banana species into Cavendish bananas successfully conferred TR4 resistance without compromising yield or quality (Dale et al., 2017). This breakthrough exemplifies how genetic engineering can provide practical solutions to urgent agricultural challenges, reinforcing the importance of effective science communication in fostering public understanding and acceptance of such technologies and food security.

Goals and Methods

This project was based on the promising results of genetic engineering in Cavendish bananas to avoid TR4 infection, and aimed to bring this story to the German and Ghanaian public, while exploring the attitudes of the different people towards genetic modifications in the food security context. Two contrasting tonalities – humorous & inspirational vs. contemptuous & dramatic – were used to convey the situation, while two different message media (text vs. video) were also used.

In order to reach the public, wide-ranging surveys were developed. Every experiment started with a pre-survey requesting general background information – age, sexual identity, education level, religious alignment. Furthermore, questions regarding participants' attitudes towards the current food security situation and genetically modified food were added. Finally, the pre-survey also contained general questions regarding their engagement with science and technology based on Okamura, 2016.

This was followed by exposure to the story, either by video or text. The tonality of this story was randomly assigned to each participant. After exposure, each participant received the post-intervention survey, containing questions regarding their fears, emotional response and opinions towards the story.

The answers to most questions were coded with LIKERT scales from 1-5 (Phillips et al., 2002), except the questions from Okamura, 2016, which went from 1-4. Furthermore, free-form questions were included in order to let the participants express their unfiltered opinions towards the story report, while also testing their information retention.

The surveys were distributed in fairs such as the Zammanand, the TUM Sustainability Day and the TUM Open Days. Furthermore the survey was introduced into the school context via the DLR School Labs. In parallel, university students were surveyed via the lectures of Prof. Werner (Computational Foundations) and Dr. Schröpfer (Sociology). The surveys aimed towards the German population were formulated in German, while the ones for the Ghanaian population were translated into English. Analogously, videos and texts were adapted to the targeted population. All data was collected through evasys. In Ghana, students were surveyed in lectures from Prof. Francis Appiah and Prof. Antwi-Agyei, and also online via the IPO website: **Enhancing Scientific Communication: Participate in Research with communicaTUM at KNUST! | International Programmes Office**

Once all data was collected, statistical analysis followed. The first step of the statistical analysis was based on clearing the dataset of any unresponsive participants, hence allowing for a better statistical analysis in RStudio. A k-cluster analysis based on Bobbitt, 2020, was performed, aiming to discover the population clusters with regards to their general attitudes towards science and technology (Okamura, 2016). Prior to that, it was necessary to perform an optimization test, aiming to discover the correct number of clusters to be assigned to our dataset. In order to realize this, two diagrams were represented (cf. Figure 1) – Number of Clusters vs. Total Within Sum of Squares & Number of Clusters vs. Gap Statistic (Tibshirani et al., 2001). With the resulting optimal number of clusters (k = 5), the k-cluster analysis was performed and each participant was categorized into one of the 5 clusters: Nominal Participants, Passerby, Interested, Onlooker and Strategic Delegators (cf. Table 1).

The code to the k-cluster analysis can be found here: https://github.com/VicenteAlgaba/communicaTUM-k-cluster-analysis.git

Building upon the k-cluster analysis, a series of correlation analyses were conducted to examine the relationships between participants' age, religious affiliation, and political stance with their trust in GMOs, concerns about food insecurity, and emotional responses (anger/fear) toward GMOs. As a preprocessing step, participants with incomplete questionnaire responses were excluded from the dataset to ensure data integrity. All analyses were performed using MATLAB.

Finally, the key part of the statistical analysis consisted of the analysis of variance (ANOVA) for the four interventions: contemptuous, humorous and for each as a text or video. Due to a sample size exceeding $n > 30$, normal distribution was assumed to apply (Corcoran, 2016). The ANOVA focused on the questions contained in the post-intervention survey. When the results reached significance, a subsequent Tukey-Test was performed indicating which interventions resulted in substantial differences in their answers and attitudes. Boxplots were produced, visualizing the differences between each of the group`s results. Furthermore, the different

cluster groups were analyzed with ANOVA based on their responses to the questions above. All analysis and data visualization was produced in MATLAB.

Results and Discussion

Cluster analysis – Germany, Munich

Prior to conducting the rigorous statistical analysis of the various conditions in our surveys, and the impact of medium and tonality on information processing, it was necessary to mathematically determine the optimal number of clusters within the sample.

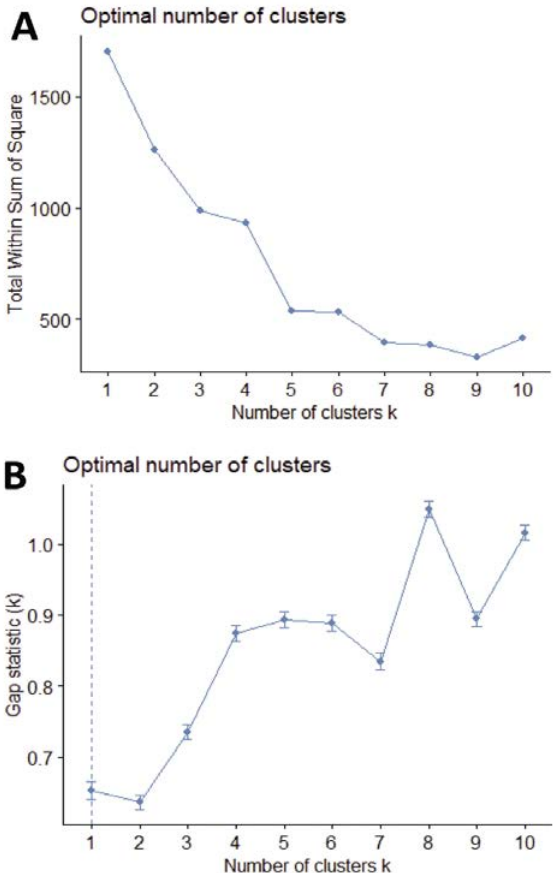


Figure 1: Optimization of cluster number via Total Within Sum of Square (A) and Gap Statistic (B) in German student population from the Technical University of Munich.

Based on the Total Within Sum of Square (A), the aim is to search for a so-called "elbow," where the sum of squares begins to level off. The lowest elbow in this diagram corresponds to k = 9. Nonetheless, given the context of a small scientific population, the local elbow in k = 5 suffices. Alternatively, based on the Gap statistic, the most optimal cluster would be the one with the highest gap statistic. Here, k = 8 seems to have the highest value. Nonetheless, we can again find a very plausible local maximum at k = 5. This was chosen to be the most optimal cluster number.

Based on this, the k-cluster analysis could start. For this, every participant was assigned to a cluster, and based on their values on science and technology engagement (cf. Supplementary Table 1 in Appendix), these clusters were named as follows:

Index	Cluster Name	Description
1	Nominal Participants	Suggests they participate to fulfill minimal requirements or expectations.
2	Passerby	Minimal engagement, emphasizing transience or incidental presence.
3	Interested	Very high interest and participation & very low delegation
4	Onlooker	Suggests someone watching with curiosity or interest, possibly with a hint of detachment.
5	Strategic Delegators	Implies a deliberate and organized approach to involvement and delegation.

Table 1: Assignment of Cluster Name based on Cluster Values based on German student population.

It must be noted that our study largely focuses on educated people surrounding the university context. This can be easily seen by the fact that parameters such as "interest" and "delegation" do not vary very strongly between the different clusters (cf. Supplementary Table 1). If compared with other large-population studies such as Okamura 2016 (Japan), it is clear that the clusters in this study tend towards having a higher "interest" in the topic. This could be explained by the fact that most of our surveys were performed in the university context, but also due to cultural differences between the Japan population towards the German population. Any conclusions taken from this study are thus specifically tailored to the educated population, and should be viewed with caution in relation to its effects on different populations as a whole.

Cluster analysis – Ghana, Kumasi

As for the collected German sample, a cluster analysis was performed on the measured data from Ghanaian students at the KNUST (n = 126).

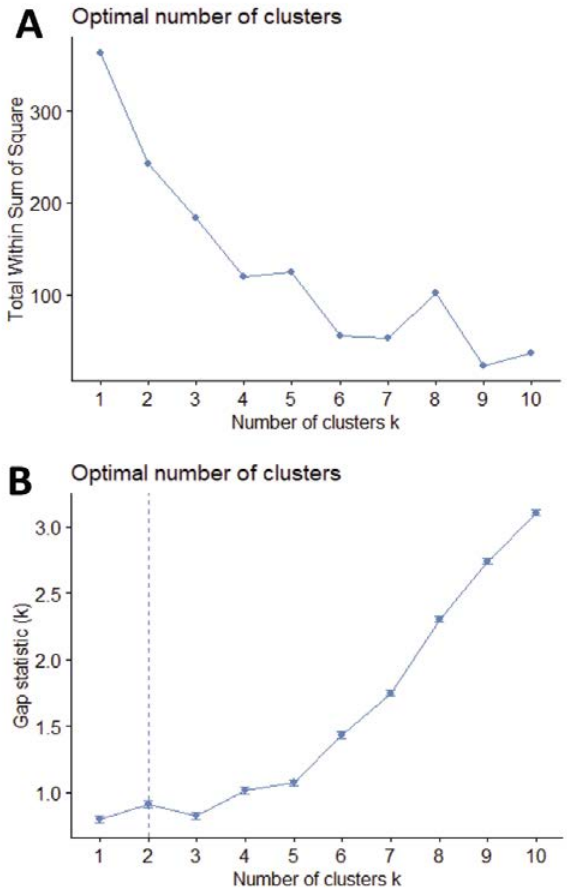


Figure 2: Optimization of cluster number via Total Within Sum of Square (A) and Gap Statistic (B) in Ghanaian student population from the Kwame Nkrumah University of Science and Technology.

Based on the same criteria as for the German population, it seemed that the most plausible cluster amount in the Ghanaian student population was k = 4. Nonetheless, with a significantly lower sample size of n = 126, the k-cluster analysis cannot be performed with the same certainty as in the German student population. As for the characteristics of the clusters itself, it was possible to find overlapping clusters between the German and Ghanaian student populations. The cluster groups "Interested" and "Strategic Delegators" could be easily found in our surveyed sample. Even so, two new different cluster groups could be found, defined as follows.

Index	Cluster Name	Description
1	Strategic Delegators	Implies a deliberate and organized approach to involvement and delegation.
2	Residual	Group that does not engage with the topic at all. Lowest interest of all, no participation and no delegation.
3	Highly invested & delegation-aware	A cluster showing mixed values between "Interested" and "Strategic delegators," People on this cluster are highly interested in the topic, participate actively in it yet are very open to delegating important decisions.
4	Interested	Very high interest and participation & very low delegation

Table 2: Assignment of Cluster Name based on Cluster Values from Ghanaian student population

It must also be noted that, while the collected sample size at the KNUST was lower, the student population there seemed to be actively more interested and engaged with the topic. While in TUM students the lowest interest mean was calculated to be 1,8 in the "Passerby" cluster, in Ghanaian students this parameter reached a minimal value of 2,5 in the "Residual" cluster, suggesting that students at the KNUST could find the topic more appealing and relevant than the German population. Given that the "Residual" cluster is only composed of 2 members, it can be said that the vast majority of our sample found food insecurity and genetic modifications a highly relevant, pressing, and thought-worthy topic.

Analysis of the post-intervention questions – Germany, Munich

This section presents the findings from the data analysis, organized into five subsections corresponding to the questions posed in the post-survey. It is important to note that the survey was conducted in German, and the questions presented here are translations of the original versions. The results are visualized using box plots, which compare the different formats (video vs. text) and tonalities

(contemptuous vs. humorous). Asterisks in the plots denote statistically significant comparisons (p-value = 0,05).

The analysis indicates that the videos had a comparatively weaker impact on participants' attitudes toward genetic modification than the texts. Notably, the "Nominal Participants" cluster displayed a more pronounced response divergence than the other clusters. Participants in this group were markedly more influenced by the text than by the videos, with their responses revealing the largest differences between the two formats. This suggests that textual content resonated more strongly with this particular cluster, potentially due to their pre-existing engagement, cognitive preferences, cultural influences or university training.

The rest of the clusters, the "Passerby," the "Interested, the "Onlooker," and the "Strategic Delegator" clusters, showed a similar

Question/Statement 1
Has the video/text changed your attitude towards genetic modification?
If so, how has your attitude towards genetic modification changed?

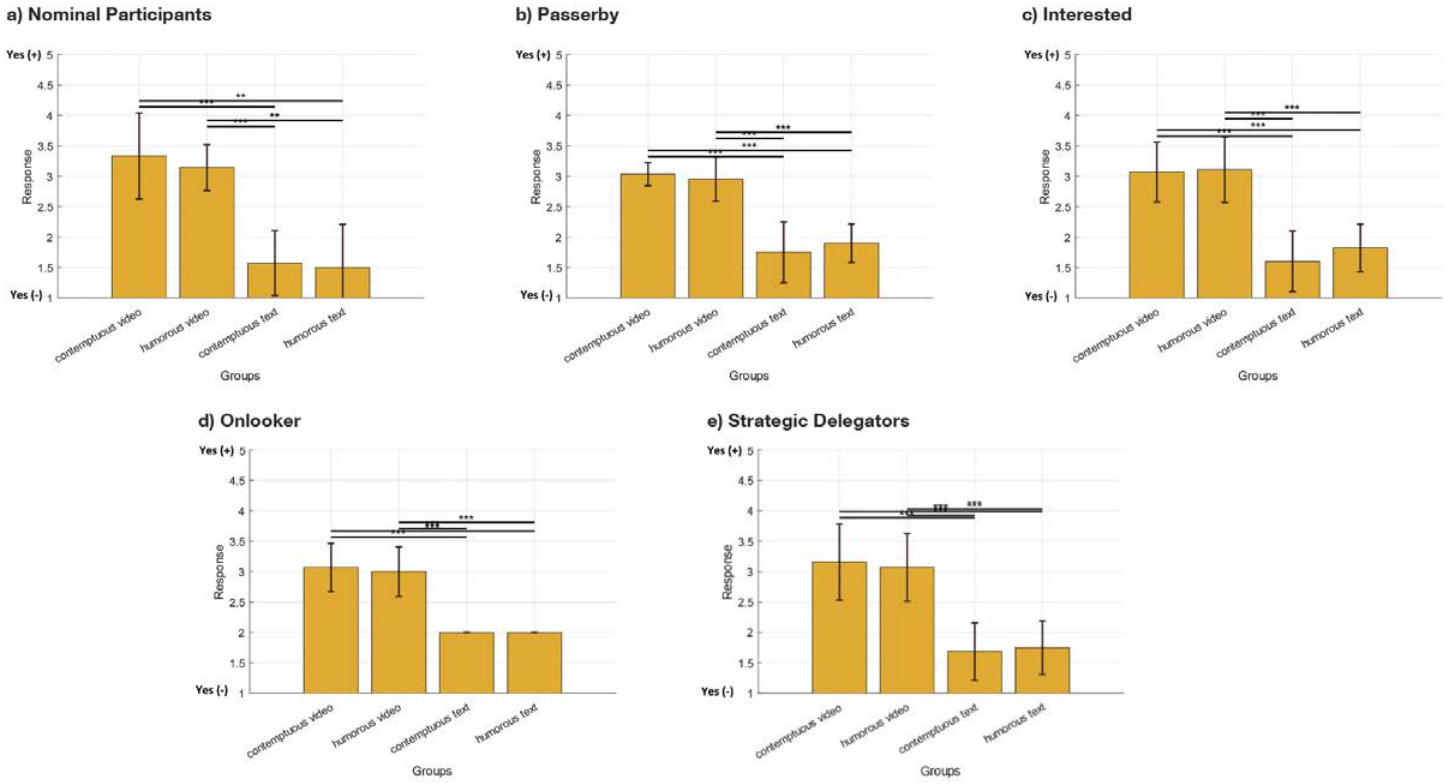


Figure 3: Response of the different German clusters to the question "Has the video/text changed your opinion towards genetic modification? If so, how has your attitude towards genetic modification changed?," Their responses were evaluated with a LIKERT scale from 1-5, with 1 being a negative change of attitude, 3 no change in attitude and 5 a positive change of attitude towards genetic modification. The clusters are a) Nominal Participants, b) Passerby, c) Interested, d) Onlooker, e) Strategic Delegators. All clusters were evaluated via ANOVA.

behavior. The box diagram for these groups, however, is characterized by a relatively flat distribution across the medium and the tonalities, indicating less variation in responses in these clusters and participants experiencing less of a shift in perspective.

Taken together, these findings underscore the varying degrees to which participants were influenced by the different formats. While textual content consistently elicited stronger negative attitudinal changes, the impact of videos was more subdued and contingent on the cluster's characteristics. Videos seemed to generate a softer response.

The data from the "Onlookers" and "Passerbys" clusters did not provide meaningful insights. The responses from these groups fluctuated around a value of 2, with no discernible trend. Additionally, the large standard deviation (on the order of 1.5 units) further

Question/Statement 2
The video/text made me angry.

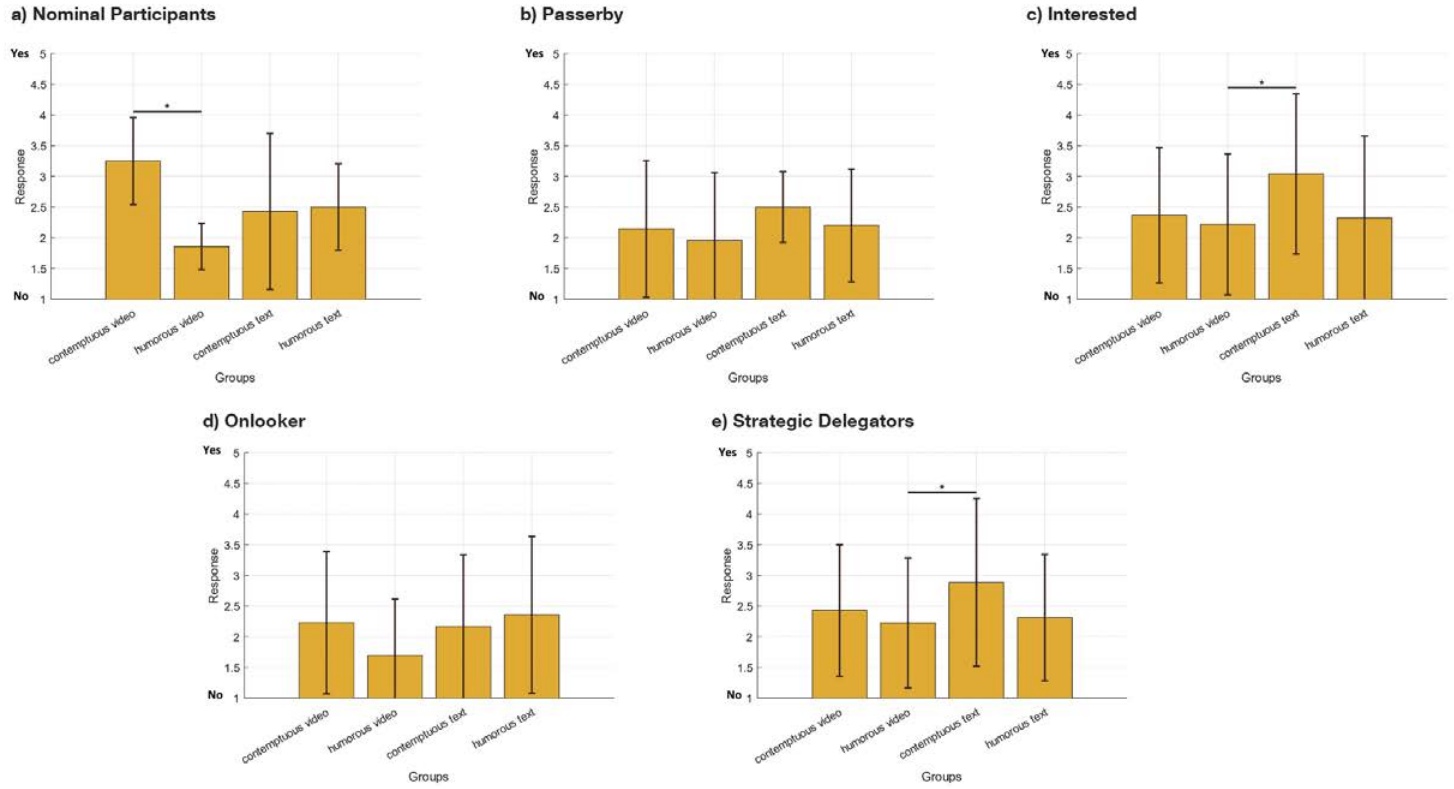
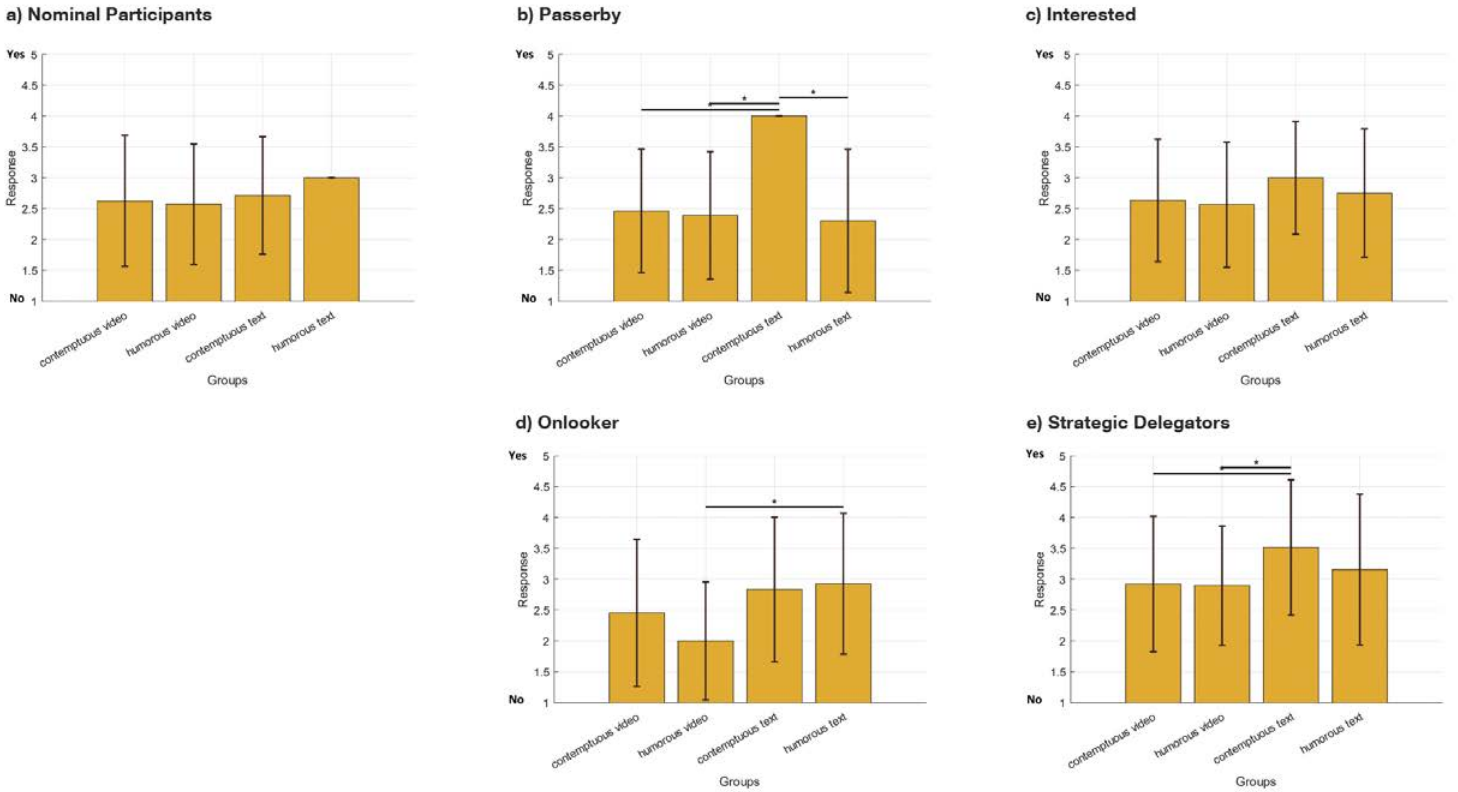


Figure 4: Response of the different German clusters to the statement "The video/text made me angry," Their responses were evaluated with a LIKERT scale from 1-5, with 1 being "No" and 5 being "Yes," The clusters are a) Nominal Participants, b) Passerby, c) Interested, d) Onlooker, e) Strategic Delegators. All clusters were evaluated via ANOVA.

limits the ability to draw reliable conclusions about these clusters. This high variability suggests that participants in these groups reacted inconsistently to the stimuli, making it difficult to identify clear patterns or effects. In contrast, the “Nominal Participants” cluster produced more insightful results. As illustrated in Fig. 4 (a), the contemptuous video elicited significantly stronger feelings of anger among these participants compared to the humorous video. It is also worth noting that the contemptuous text elicited highly varied reactions, as indicated by its large standard deviation.

Finally, the “Interested” and “Strategic Delegators” clusters exhibited similar response patterns, which differed markedly from those of the “Nominal Participants.,” Both clusters reported significantly stronger feelings of anger in response to the contemptuous text compared to the humorous video, with a difference of more than one unit on the response scale. While the “Nominal Participants” were more sensitive to the tonality of the video, the “Interested” and “Strategic Delegators” were more strongly influenced by both the tone and the difference in the medium.

Question/Statement 3
I feel that I need to take a political stance against the issue of food insecurity.

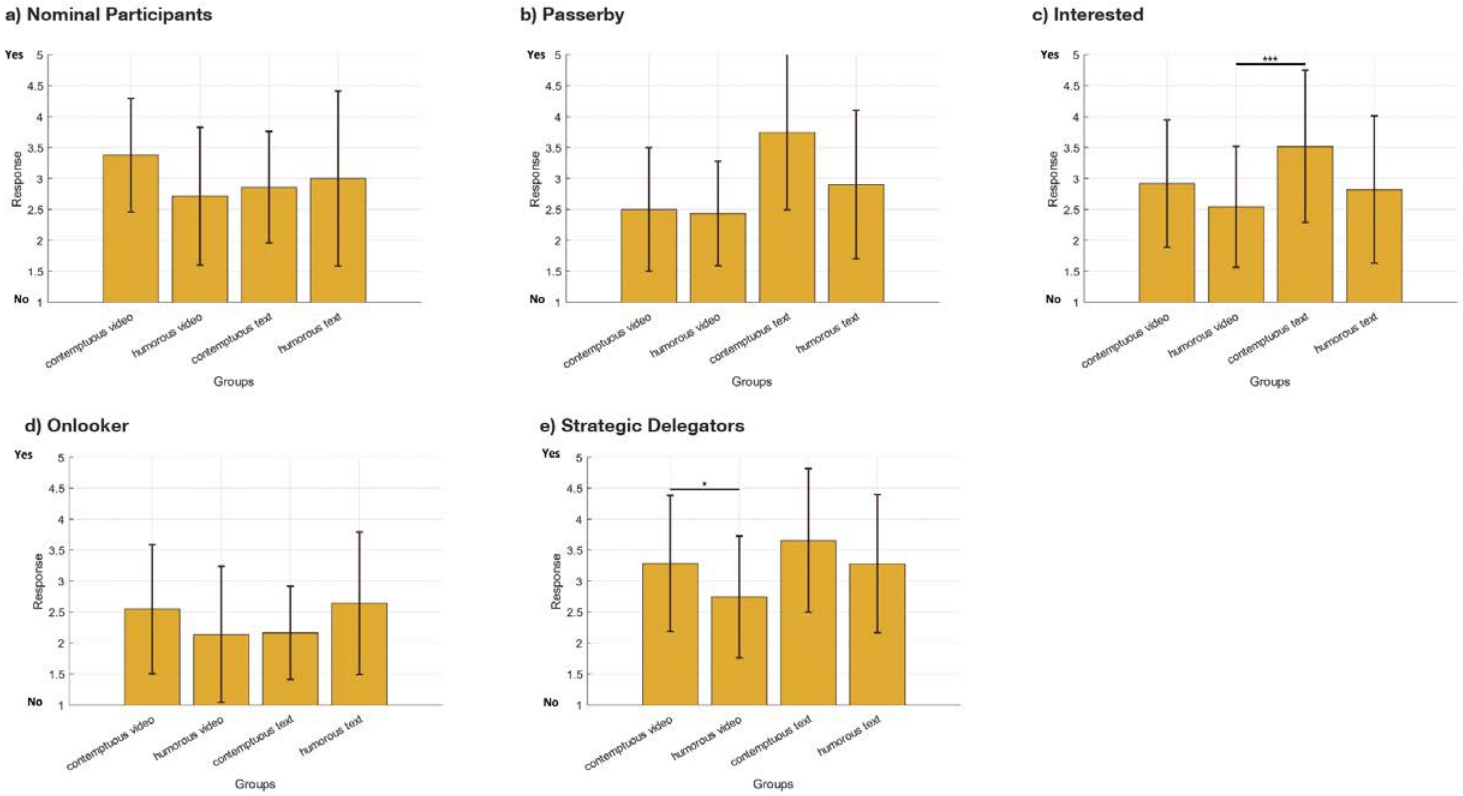


This statement elicited very similar reactions from both the "Interested" and "Nominal Participants" clusters. However, the responses from the "Passerby" cluster provided more meaningful insights into the effects of medium and tonality. The contemptuous text emerged as the most influential stimulus, evoking a stronger sense of urgency to take a political stance against food insecurity compared to all other formats and tonalities. The mean response for the "Passerby" to the contemptuous text was 4 out of 5, significantly higher than the responses to other stimuli, none of which exceeded 2.5 units. This stark contrast highlights the unique effectiveness of the contemptuous text in mobilizing this particular cluster.

The "Onlookers" cluster exhibited a more intense reaction to the humorous text than to the humorous video, with mean response values of approximately 3 and 2, respectively. However, no other statistically significant comparisons could be made for this cluster, limiting further conclusions about their responses.

Finally, the "Strategic Delegators" cluster displayed a response distribution that resembled a flattened version of the "Passerby" distribution. Similar to the "Passerby," the contemptuous text evoked the strongest feelings among the "Strategic Delegators," However, this effect was only statistically significant when com-

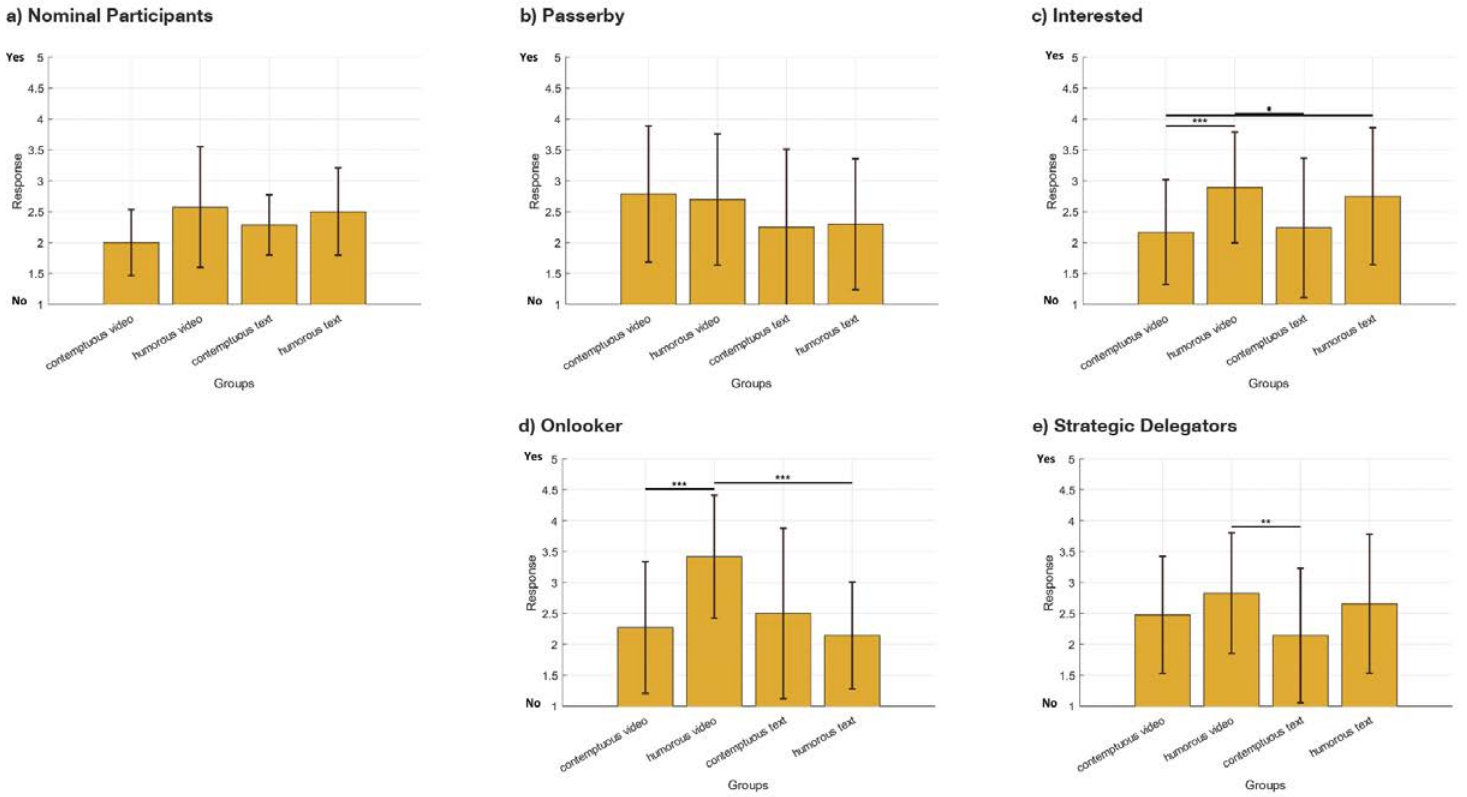
Question/Statement 4
The video/text raised concerns for me.



pared to the video formats, not when compared to the humorous text. This suggests that while the contemptuous text was impactful, its influence was not uniformly dominant across all comparisons within this cluster.

The clusters “Nominal Participants” and “Onlooker” did not provide significant insights in the context of the statement about raised concerns. Analogously to Statement 3, the “Passerby” cluster seemed to show an increased amount of concern after reading the contemptuous text, which also correlates to the increased feeling of having to engage politically with the topic (cf. Fig. 5, b). For the “Interested” cluster, the key finding is that the contemptuous text was also more effective in raising concerns compared to other formats and tonalities. None of the other comparisons within this cluster reached statistical significance, underscoring the unique impact of the contemptuous text on this group. But, even though this cluster`s concerns were raised by the contemptuous text, their response in having to take a political stance did not increase in comparison to the “Passerby” group (cf. Fig. 5b, c), probably because the “Interested” group already partakes in political activities on this matter.

Question/Statement 5
The video/text left me with the impression that the situation is under control.



The “Strategic Delegators” cluster exhibited a distinct pattern: participants in this group were more concerned by both the contemptuous text and the contemptuous video than by the humorous video. Interestingly, the statistical significance and the magnitude of the difference were stronger between the contemptuous text and the humorous video than between the contemptuous video and the humorous video. However, no conclusions can be drawn regarding the comparison between the contemptuous and humorous texts, as this difference did not reach statistical significance.

While the contemptuous text consistently emerged as a powerful stimulus, its impact was most pronounced among the “Interested” and “Strategic Delegators” clusters. The lack of significant results for the “Nominal Participants”, “Passerby”, and “Onlooker” clusters suggests that these groups were less responsive to the stimuli in the context of raised concerns.

The responses from the “Nominal Participants” and “Passerby” clusters did not provide meaningful insights into whether participants felt the situation was under control. The data from these groups lacked clear trends or statistical significance, making it difficult to draw any conclusions about their perceptions.

In contrast, the “Interested” cluster exhibited a more insightful distribution in response to this statement. The humorous video left participants with a significantly stronger impression that the situation was under control compared to both the contemptuous video and the contemptuous text. Additionally, an interesting comparison can be made between the humorous text and the contemptuous video: the latter left participants feeling less confident that the situation was under control. However, no other comparisons reached statistical significance, limiting further conclusions for this cluster.

The “Onlookers” cluster also demonstrated notable patterns. Participants in this group felt significantly more confident that the situation was under control after viewing the humorous video compared to the contemptuous video and the humorous text.

The humorous video consistently emerged as the most effective in fostering a sense of control, particularly among the “Interested” and “Onlookers” clusters. However, the lack of significant results for the “Nominal Participants”, “Strategic Delegators” and “Passerby” underscores the challenges of engaging these groups on this issue.

Quantitative comparison Kumasi/Munich

The research team also had the opportunity to conduct the survey in Kumasi, Ghana. In the following analysis, we compare the responses of participants from Bavaria and Ghana. To ensure consistency in the comparison, only the video-based component of the survey was considered for the Bavarian sample, as the Ghanaian participants were likewise exposed solely to the video and not the text-based medium.

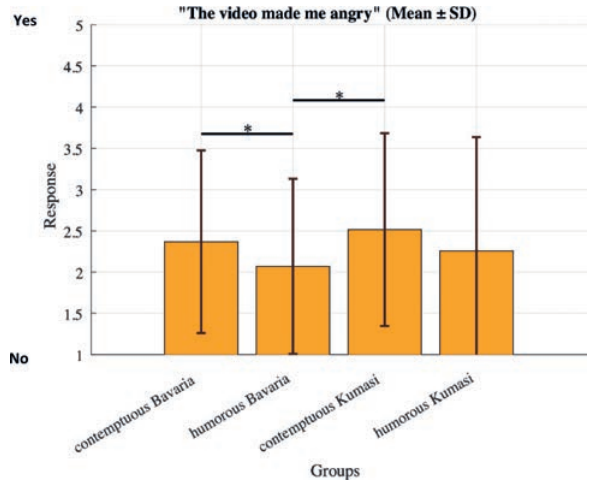


Figure 8: Mean response of the German and Ghanaian populations to the statement “The video made me angry,”

In response to the question of whether the video elicited anger, both populations exhibited similar overall trends. However, the contemptuous video appeared to provoke stronger feelings of anger among the Ghanaian participants compared to the humorous video among their Bavarian counterparts.

The responses to the question “Has the video changed your attitude towards genetic modification?” reveal more pronounced differences between the groups compared to the previous item. The contemptuous video had a significantly stronger impact on the attitudes of the Ghanaian participants than on those of the Bavarian participants, regardless of which video the latter viewed. Notably, the humorous video also elicited a marked shift in attitudes among participants in Kumasi, with their mean response reaching 4 out of 5 points – higher than any other group in the study.

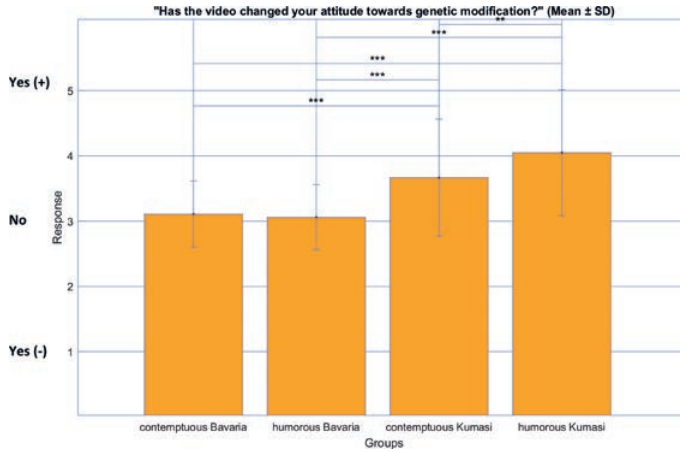


Figure 9: Response of the Ghanaian and German population to the question "Has the video changed your attitude towards genetic modification?,"

When asked whether the video raised concerns for them, participants in Kumasi reported significantly higher levels of concern on a five-point Likert scale. Both the humorous and the contemptuous videos elicited comparable levels of concern among the Ghanaian participants. In contrast, the German participants, on average, reported lower levels of concern across both video conditions.

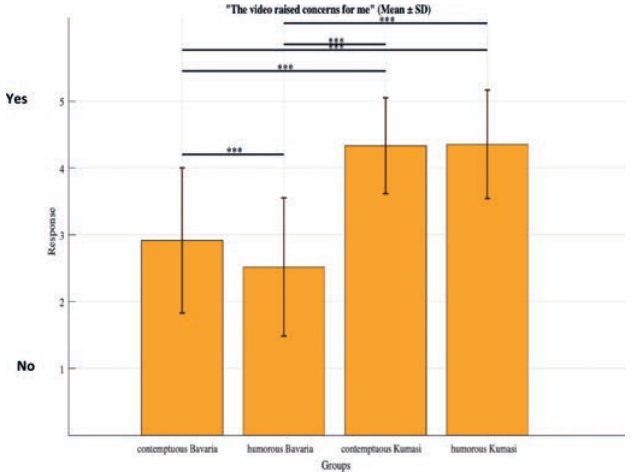


Figure 10: Response of the Ghanaian and German population to the statement "The video raised concerns for me,"

Regarding the question of whether the video left participants with the impression that the situation is under control, a discernible trend emerges in the data. German participants tended to be more pessimistic in both video conditions, with mean responses falling below the neutral midpoint of 3. This effect was more pronounced following the contemptuous video, which conveyed a weaker sense of control. In contrast, Ghanaian participants were generally more optimistic, particularly in response to the humorous video, which conveyed a stronger impression that the situation is manageable. In this case, both the comparisons between video types and between countries yielded statistically significant differences.

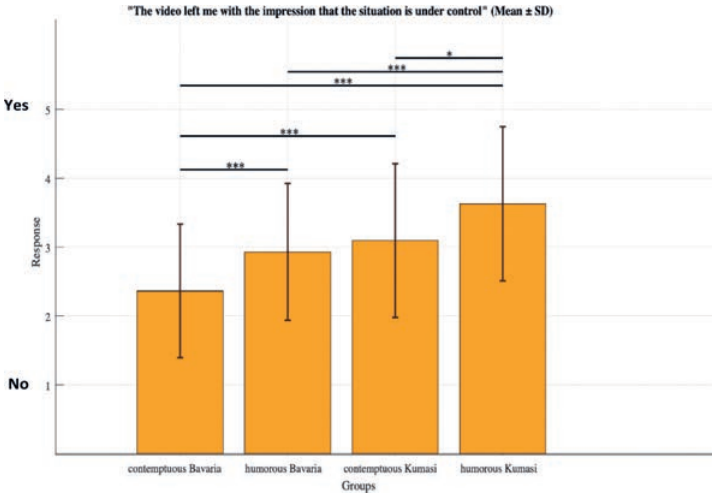


Figure 11: Mean response of the Ghanaian and German population to the statement "The video left me with the impression that the situation is under control,"

Finally, in response to the question of whether they felt the need to take a political stance against the issue of food insecurity, participants in Kumasi responded more affirmatively than their Bavarian counterparts. The Bavarian participants showed similar response levels across both video conditions, with mean values slightly above 2.5 on the five-point scale. In contrast, the Ghanaian participants reported a significantly stronger inclination to take political action, particularly after viewing the humorous video, which yielded a mean response slightly above 4. The contemptuous video also prompted elevated responses in Kumasi, though to a lesser extent, with a mean around 3.5.

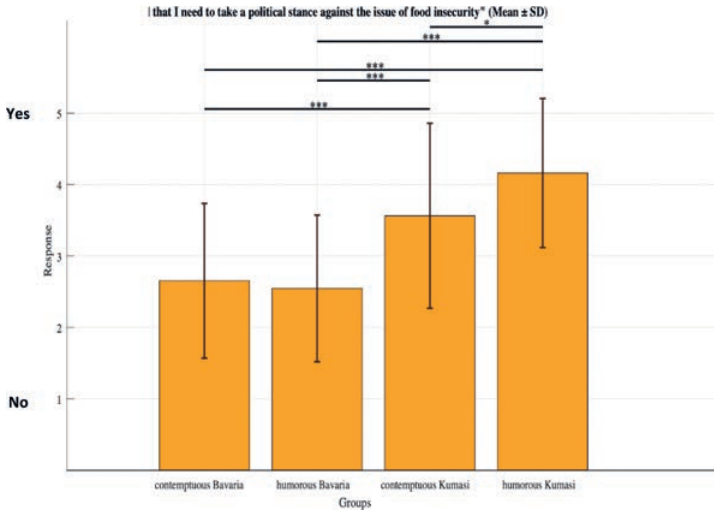


Figure 12: Mean response of the Ghanaian and German population to the statement "I feel that I need to take a political stance against the issue of food insecurity,"

Qualitative analysis – Comparison Munich/Kumasi

While most questions were designed to be analyzed quantitatively, the survey also contained two especially relevant free-text questions that elucidate very interesting behaviors:

1. How do you believe the increasing food insecurity would affect you personally?
2. Did you like the video? Do you have any general remarks?

With regard to Question 1, the socioeconomic disparities between the respective student populations become evident. A significant majority of the surveyed Ghanaian participants responded with "A lot" or "It will affect me/my […]," highlighting the tangible threat that food insecurity poses in their context. In contrast, most of the German respondents indicated "Not much" (eher wenig/kaum) or "Not at all" (gar nicht/nicht wirklich), suggesting a lower perceived personal risk. Nevertheless, while a substantial portion of German students did not perceive food insecurity as a direct threat to themselves, many were able to recognize its potential impact in so-called "third world countries." Despite this awareness, the fact that a large proportion of TUM students did not perceive any significant threat—either to themselves or to others—raises a point of concern.

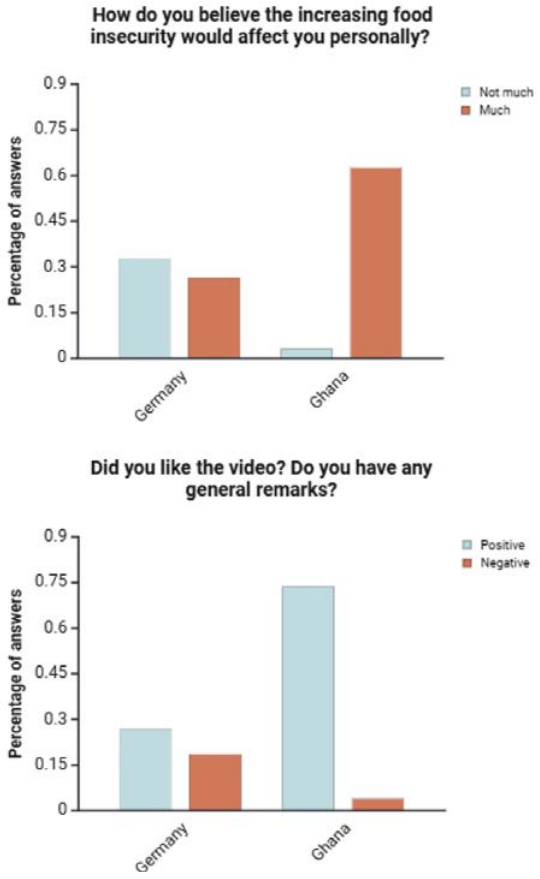


Figure 13: Overview of percentage of answers to Questions 1 and 2 from the surveyed student populations in Germany and Ghana.

With regard to Question 2, responses suggest that Ghanaian participants generally received both video types positively, with several noting that the content effectively addressed the topics of food insecurity and genetic modification. Representative comments included: "It was very impactful," "Yes," "[…] I liked it," and "Yes! Very short and educative." In contrast, a notable proportion of TUM students described the videos as "boring" (langweilig), "condescending," "confusing" (verwirrend), "unserious" (unseriös), or "not very informative" (nicht sehr informativ). These contrasting evaluations may reflect broader cultural differences in communi-

cation expectations and critical reception between the Ghanaian and German-affiliated student groups. Additionally, the comparatively higher perceived danger of food insecurity among KNUST students (cf. Figure 13) may have contributed to a more favorable reception of the video content.

Sociodemographic Correlation of Attitudes Toward GMOs

We compared correlations between demographic factors and attitudes toward GMOs in Germany and Ghana. In both countries, age correlated significantly with trust in GMOs (Germany: $p = 0.0001$; Ghana: $p = 2.47\times10^{-5}$). However, only in Germany did religion and political orientation also correlate with trust (religion: $p = 4.92\times10^{-11}$; politics: $p = 0.0061$), whereas in Ghana, these associations were not significant ($p > 0.26$).

Regarding concerns about food security, only political orientation was significantly associated in Germany ($p = 0.0004$), while in Ghana, both religion and political orientation were significant (religion: $p = 0.0214$; politics: $p = 0.0342$). Age showed no significant correlation in either country.

For emotional responses to GMOs, Germany showed a broader pattern of associations. Age was significantly correlated with anger ($p = 3.23\times10^{-4}$) but not with fear ($p = 0.0056$, above threshold). Religion correlated with both anger and fear (anger: $p = 0.0020$; fear: $p = 2.46\times10^{-5}$). In Ghana, only religion was significantly correlated with fear ($p = 0.0048$); all other associations were not significant ($p > 0.05$). Notably, political orientation did not correlate with emotional reactions in either country.

Summary and Future Goals

Effective science communication plays a more important role than ever in today's age of social media and fast-paced life. While it is essential to present complex facts in a way that the general public can understand, it is also important to consider the emotional impact on the audience. Anxiety as a reaction to intense news can lead to resignation and hopelessness instead of encouraging people to approach problems with confidence and a solution-oriented mindset.

What makes us human is the ability to experience emotions and to decide how we react to them. As part of #class24 of TUMJA, our research group *communicaTUM* set out to investigate how people react to different communication styles on controversial and complex topics. To explore this, genetically modified organisms (GMOs) were chosen as the subject. The same information was presented in two different tonalities: one humorous & inspirational and the other one contemptuous & dramatic.

First, a pilot study was conducted, where participants provided demographic data, religious beliefs, political interests, and attitudes toward science and GMOs. They then read a text about genetically modified bananas. One group received a humorous & inspirational version, while the other received a contemptuous & dramatic version. Afterward, participants were asked how they felt, whether the text had changed their attitude toward GMOs, and whether they felt compelled to take action. In this study, 167 people participated.

In the next stage, the texts were replaced by videos. These were recorded by a professional dubbing artist and featured only minor differences in video footage to ensure comparability. Data was collected through various science outreach events, university gatherings, the DLR school lab, and online surveys, with most participants being 16–25 years old. All responses were collected anonymously to ensure unbiased results. A total of 413 participants took part in the video study, of whom 203 watched the humorous & inspirational video and 210 watched the contemptuous & dramatic video. Both the pilot and final studies were conducted in German.

To add another dimension of comparison, an additional study was conducted in Ghana, at the Kwame Nkrumah University of Science and Technology. For this, the survey was translated into English, and the videos were reproduced. A sample size of $n = 126$ Ghanaian students were actively engaged with the survey, making the total sample size of this study 706 people.

In the German study, participants who watched the contemptuous & dramatic video reported higher levels of worry and anger, while those who watched the humorous & inspirational video felt slightly more in control of the issue. However, when asked whether their stance on GMOs had changed, both groups showed similar responses, with only a slight tendency toward a more positive perception in the dramatic & contemptuous video group. Additionally, the dramatic & contemptuous tone led to a greater inclination to take political action regarding food insecurity, although the effect was moderate. Some participant groups showed more pro-

nounced reactions to the texts than to the videos, regardless of tonality, indicating that individual engagement styles may play a role in how scientific messages are received. While tonality influenced emotional responses, the medium of the message—text vs. video—had a stronger impact on shaping attitudes toward GMOs.

In comparison to our surveyed German sample, the Ghanaian students reacted more positively to almost all questions except to anger (cf. Fig. 8), showing a significantly higher level of engagement, concern, trust and open mindedness than had been analyzed in Germany. Furthermore, the humorous video seemed to achieve more positive results in attitude changes, calmness and political activity (Figs. 9, 11, 12).

In conclusion, our study showed that tonality does influence how people perceive and process information, especially among the scientifically educated German and Ghanaian population. Messages delivered in a dramatic and contemptuous manner can increase engagement and change opinions. Notably, the impact of sociocultural status is very high, as shown by the different attitudes towards the video in Figs. 8-12 and Fig. 13. It is striking to see how the more personally challenged Ghanaian population showed an increased openmindedness, proactiveness and engagement towards the topic of food insecurity and possible GMO solutions.

This raises the broader question of what science communication should aim to achieve. How can we ensure that scientific information is presented in an understandable and neutral way without contributing to the increasing polarization we observe nowadays? Especially in an era where people are overwhelmed with negative and anxiety-inducing information, it is crucial to strike a balance and to convey the seriousness of an issue without amplifying fear and resignation. Future research should further explore how different communication strategies influence public perception and induce proactiveness. The goal should be to make complex scientific information accessible and understandable for everyone while ensuring that people can form their own opinions on controversial topics based on facts rather than emotions or misinformation.

Appendix

cnum	count	interest mean	interest sd	participation mean	participation sd	delegation mean	delegation sd
1	25	1.840000	0.3741657	2.920000	0.6403124	3.240000	0.7788881
2	72	3.777778	0.4186572	1.875000	0.3330398	2.777778	0.5366097
3	170	3.717647	0.4514740	3.194118	0.3966883	2.794118	0.4728994
4	105	3.866667	0.3415650	1.771429	0.4219265	4.000000	0.0000000
5	196	3.811224	0.3923323	3.326531	0.4701448	4.000000	0.0000000

Supplementary Table 1: Summary Values of Cluster Analysis based on Science and Technology Engagement in German student population (TUM). Values marked in blue and orange correspond to the clusters similar to the Ghanaian population from Supplementary Table 2.

cnum	count	interest mean	interest sd	participation mean	participation sd	delegation mean	delegation sd
1	18	3.833.333	0.3834825	3.000.000	0.0000000	4.000.000	0.0000000
2	2	2.500.000	21.213.203	1.000.000	0.0000000	2.000.000	0.0000000
3	52	3.942.308	0.2354355	4.000.000	0.0000000	4.000.000	0.0000000
4	42	3.809.524	0.3974366	3.261.905	0.4450006	2.857.143	0.3541688

Supplementary Table 2: Summary Values of Cluster Analysis based on Science and Technology Engagement in Ghanaian student population (KNUST). Values marked in blue and orange correspond to the clusters similar to the German population from Supplementary Table 1.

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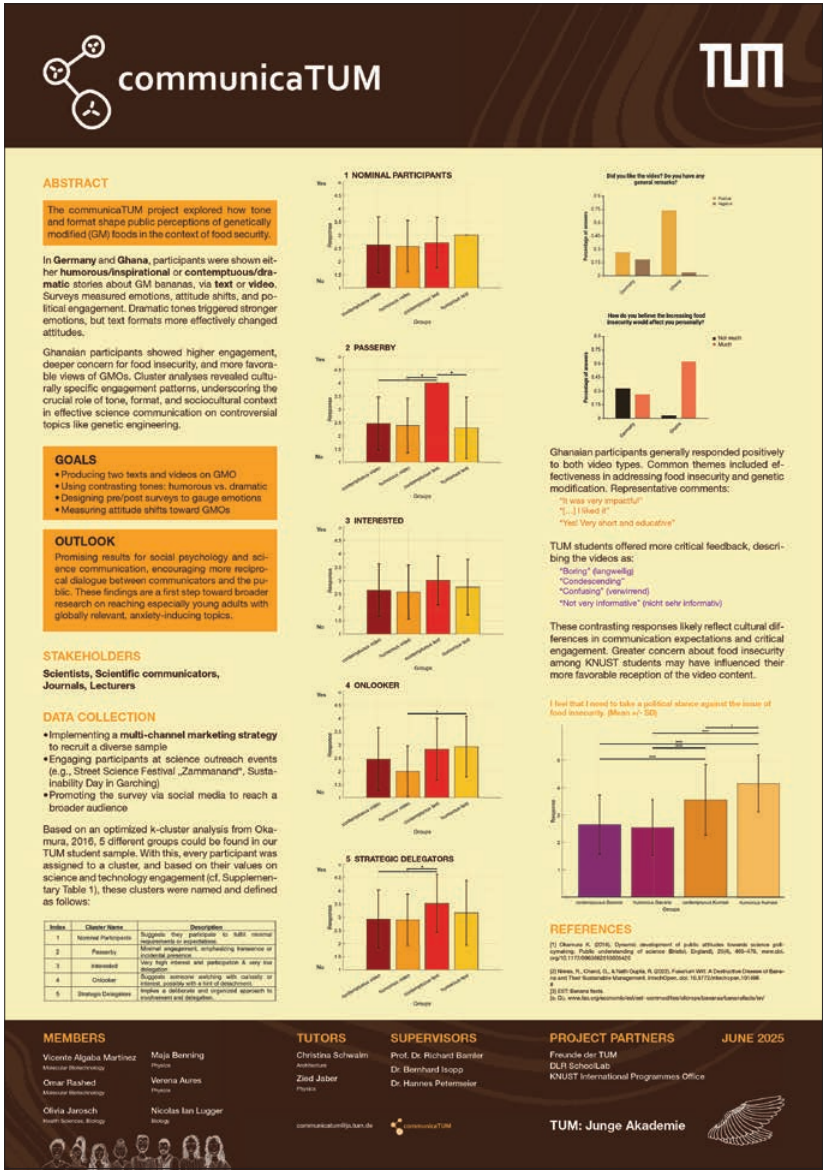
Process description

Project communicaTUM investigated how different tones and formats in science communication influence emotional reactions and perceptions of genetically modified organisms (GMOs). The hypothesis was that tone and format would affect participants differently depending on their background and level of engagement. To explore this, the team developed short videos and texts about genetic modification, using either a humorous or contemptuous tone.

Surveys were designed to collect demographic data, emotional responses, and changes in attitudes toward GMOs. Data was gathered from June 2024 to March 2025 during events such as the TUM Sustainability Day, the Zamanand Festival, and through university lectures at the Technical University of Munich and the Kwame Nkrumah University of Science and Technology in Kumasi during a research trip. Participants completed a pre-survey, engaged with the videos, and answered a post-survey.

The interdisciplinary team from life sciences, physics, and architecture, allowed for an effective division of tasks: content development, statistical analysis using RStudio and MATLAB, and visual design were handled according to each member's academic background. The results showed that "Nominal Participants" responded primarily to the tone, while "Interested" and "Strategic Delegators" were influenced by both tone and format. Overall, a contemptuous tone tended to evoke stronger feelings of anger, while a humorous tone helped foster a greater sense of control, particularly among Ghanaian students.



Self-Reflection communicaTUM

The Team

Project communicaTUM began as one of the largest teams in #class24, with a total of nine members. However, the early days were challenging – three members left within the first few months, which had a significant impact on the team, leading to lower morale and a heavier workload. Despite this, the remaining members quickly developed a strong understanding and connection, which allowed the team not only to survive but to truly thrive.

Although we never had a dedicated team-building event, we've always seen every meeting and seminar weekend as a chance to bond and grow together. We made sure to bring fun into every activity – and we're especially proud of our regular adventures during the seminar weekends!

Furthermore, through our team's active involvement in science fairs, events, and lectures, our bond grew stronger than ever. Even during the cold, rainy days of the Zammanand, we found comfort in each other's company. And, while the work was intense, we all had a blast!

Finally, some of us had the incredible opportunity to visit our partner university in Ghana, the Kwame Nkrumah University of Science and Technology. During our stay, the team carried out a second round of surveys with Ghanaian students, gathering responses from 126 participants. But it wasn't all work! In just a few days, the team managed to explore the country extensively, discovering many of the beautiful sights and experiences Ghana has to offer. It was a deeply meaningful journey that brought us closer – not just through shared sleepless nights, but through a genuine sense of connection and family.

Thanks to everyone for making this experience possible!

- Vicente Algaba
- Verena Aures
- Maja Benning
- Zied Jaber
- Olivia Jarosch
- Nico Lugger
- Omar Rashed
- Christina Schwalm
- Prof. Bamler
- Dr. Isopp

Research Report **InsEYEght**

Despite advances like self-driving cars, daily tasks such as grocery shopping remain difficult for the visually impaired. Since they make up a small portion of the population, AI solutions tailored to their needs remain an underdeveloped niche market. Yet, fully harnessing AI's potential could be transformative. Our research addresses this by examining both everyday challenges and the current assistive tools, aiming to bridge the gap between AI's potential and its real-world application for the visually impaired.

Team
Chiara Deleu
Joshua Fehn
Liza Saneblidze
Maximilian Hillgärtner
Max Schultz
Oliver Meixner
Samuel Clemens Friese

Tutors
Martin Zirngibl
Monica Déchène

Supervisor
Prof. Dr. Johannes Betz

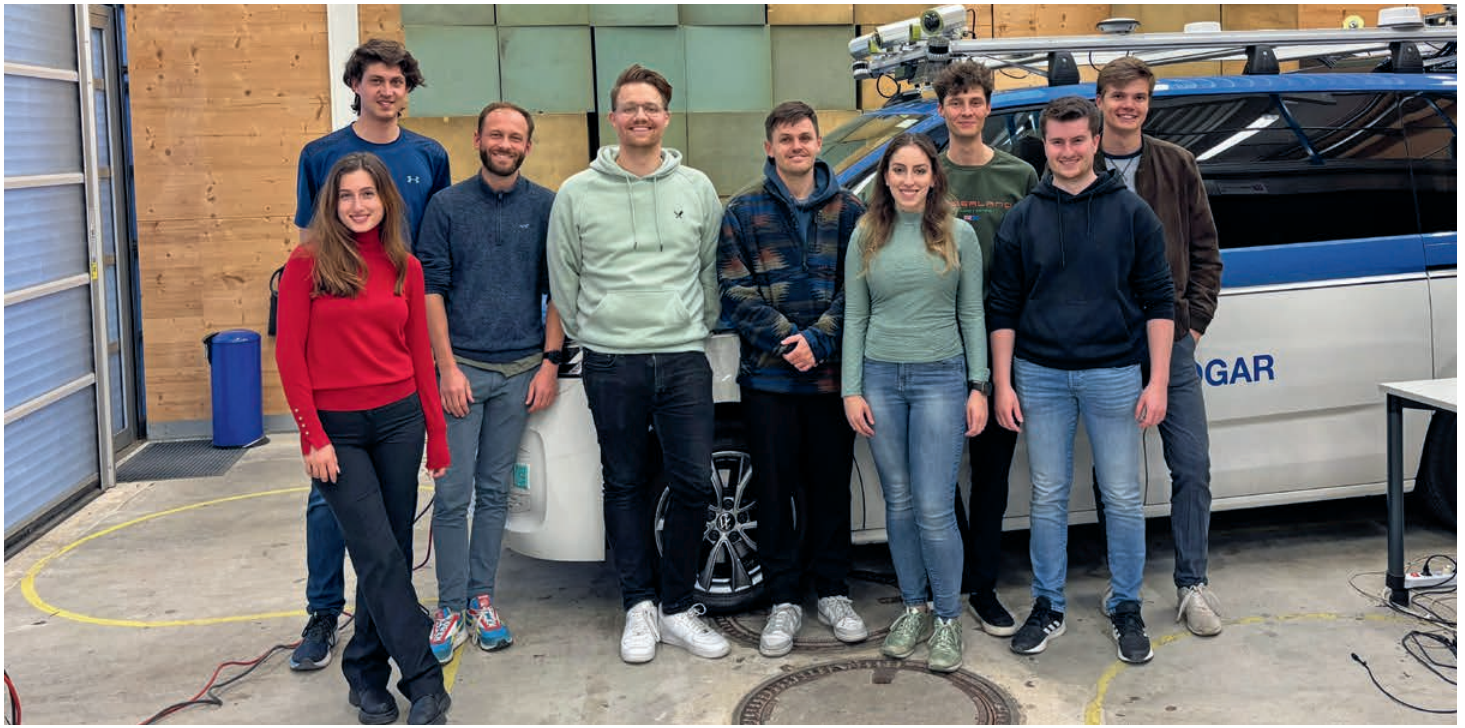
Preface by the Supervisor

Prof. Dr.-Ing. Johannes Betz

The importance of ensuring safety and accessibility in public spaces for blind and visually impaired individuals cannot be overstated. As our cities become more complex and technologically advanced, so must our efforts to include and protect all members of society. The insEYEght team of #class2024 focuses mainly on this challenge. It has the potential to raise awareness, identify real-world needs, and drive meaningful innovation in areas that often receive too little attention.

What makes the endeavor of the team insEYEght particularly valuable is its interdisciplinary foundation. When expertise from different fields – engineering, medicine, informatics, and beyond – comes together, it creates a fertile ground for creative, holistic solutions. This blending of perspectives is a strength and a necessity when addressing complex societal issues. It reflects the reality of modern research and innovation, where collaboration across disciplines leads to deeper understanding and more impactful outcomes. The project insEYEght stands out as a highlight for its empathetic and research-driven approach to understanding the needs of blind and visually impaired individuals, combining technical innovation with social responsibility to create real impact.

It is encouraging to see critical societal questions tackled with seriousness, empathy, and scientific rigor. The outcomes of this work will extend far beyond technical solutions; they will contribute to a broader culture of awareness, respect, and inclusion.



Supervisor Insights

What is your research interest or motivation for science?
My research centers on autonomous systems, intelligent mobility, and the interaction between humans and machines. What motivates me most is the opportunity to develop technologies that can directly improve lives – whether it's through making traffic safer, cities smarter, or, in this case, public spaces more inclusive. Science gives us tools to solve real problems, and that translation from theory to tangible impact is what keeps me engaged and excited.

What was your best TUMJA moment?
One of my favorite TUMJA moments was witnessing a team's initial concept evolve into a real idea and solution through collaboration and shared passion. That transformation – from idea to impact – never gets old. But above all, it's the genuine curiosity, energy, and commitment of the scholars that impress me every time.

What does mentoring the team mean for your own research?
Mentoring this team is a refreshing and inspiring process. It pushes me to rethink familiar problems through different lenses and constantly challenges my assumptions. The exchange is never one-way – guiding young researchers sharpens my own thinking and creates new research questions.

What experiences do you relate to talent mentoring programs?
Mentoring programs like TUMJA are a unique breeding ground for interdisciplinary collaboration. I've seen firsthand how talented individuals from diverse fields come together and achieve things no single discipline could accomplish alone. My experience has shown that mentoring is not just about knowledge transfer – it's about unlocking potential and nurturing curiosity.

What experience from your studies/career would you like to share with the scholars?
One experience that shaped me deeply was working on my first real-world autonomous vehicle project. It taught me how messy, unpredictable, and rewarding innovation can be. The biggest lesson: Don't be afraid of failure! – Failure is often the best teacher.

How did your work as a supervisor influence you individually?
Supervising students has taught me to be more patient and has pushed me to rethink how I communicate complex ideas. It's made me more aware of how I explain content and how important clarity is when working with people from different backgrounds.

The Journey of insEYEght

Overcoming Invisible Barriers: The Promise of AI for the Visually Impaired

Let's imagine: It's early in the morning. Your alarm rings, but instead of simply checking your phone, you carefully feel around your nightstand until you find your talking clock. Still drowsy, you get up, but even the short walk to the bathroom presents the first challenge: Did you leave everything in its place last night? A misplaced chair can already turn into a dangerous obstacle.

Does this sound unfamiliar to you? If yes, it is probably because, for people with no visual impairment, it is hard to put themselves into this position. The affected, however, face innumerable challenges in every aspect of life that most people do not even consider: Is this a tinned can with pineapples or pickles? On which platform is bus number 74 leaving?

Fully sighted people hardly realize the challenges visually impaired people have to tackle. One thing they do realize instead is the racing technological progress that is reshaping the world around them. This contrast highlights a deeper issue at play: our ability to innovate often outpaces our ability to reflect on how those innovations affect all members of society. Or to put it in the words of Yuval Harari: *“Humans were always far better at inventing tools than using them wisely.”*

While some are afraid of the disruptive power of AI, others praise its vast potential. Utilizing the unprecedented potential of AI might include more sophisticated aid tools for blind people. However, other applications like autonomous driving attract the most attention. Indeed, they affect all of us and are therefore more profitable for economically driven companies. This suggests that applications for visually impaired people are still underdeveloped, even if they are receiving more attention. From an economic point of view, the visually impaired might be considered a niche target group. But from a humanistic perspective, the situation looks very different: as a vulnerable group that relies more heavily on external support, their needs should be prioritized.

We, as humans, must not forget that at some point in our lives, we all depend on the help of others – whether as newborns, in old age, or when facing challenges that limit our independence, such as temporary or permanent impairments. What makes us human? Certainly, phases of vulnerability and dependence at some points in our lives. But also, the urge to overcome these dependencies and the necessary creative power are among the most valuable human assets. And perhaps most profoundly, empathy. The ability to put ourselves into the position of another individual, trying to understand their feelings and needs, changes the way we treat others, shapes our societies, and thus is a crucial part of what makes us human.

This is why the team InsEYEght chose to respond to the call of this year’s class by exploring the potentials of the latest technology for visually impaired individuals.

The project was supervised by Johannes Betz, a professor of autonomous driving at TUM. His impressive demonstration of what is already technically feasible shaped the project's core rationale:

"Much of the technical foundations are already there; all it needs for supporting visually impaired people is a context-specific adaptation." Learning more about the needs of visually impaired people and their struggles with traditional aids could enable the implementation of AI in suited problem areas. In this pursuit, we conducted interviews with affected individuals.

The insights into the everyday life of the affected quickly made clear that "To see, or not to see, is not the question here." When talking about visual impairments, one must distinguish much more than "sighted and blind." The range between these two extremes covers multiple different visual disorders, all with unique characteristics and thus with special needs regarding aid tools. For example, people with visual impairment since birth tend to emphasize a signalling function of aid tools; people affected later in their lives prefer aid tools which are less noticeable and leave them "undercover."

This illustrates that expectations about aid tools are very individual, which makes highly adaptable AI a promising solution. However, the data from the interviews also shows that blind people and their aid tools keep up with the times. For some traditional aid tools, "smart" versions exist, such as blindness canes with ultrasonic obstacle detection. However, many of these functional upgrades have usability downgrades; in the case of smart canes, many users mention the increased weight as a severe limitation. Furthermore, the smartphone paired with certain apps is nowadays the most used aid tool, especially when the focus lies on information gathering rather than obstacle detection. *"We have found visually impaired people, especially in older age-brackets, to be very technologically experienced and open. While sighted people could perfectly well find their way in the world 30 years ago, visually impaired people always struggled. Hence for sighted people the incentive to deal with new technology is much smaller than for visually impaired people. For the latter, smartphones bear too much potential for people to miss out on, so they make an effort to get into the latest technology,"* summarizes Max, one of the team members. This is fundamental for the pursuit of InsEYEght, as it shows that visually impaired people are already confident with technology and thus smartphones are a promising platform for establishing AI-aided tools. In addition, dedicated hardware, such as glasses or devices with haptic feedback, are also feasible if required.

Another finding from systematically surveying the aid tools already in use is that apps for many applications already exist. Sometimes when participants talked about a particular problem, this would prompt others to report that a solution tailored to this problem already exists. It goes without saying that enhancing the usage of what is already on the market is more straightforward than developing anything new.

The findings of our research contribute to addressing the most pressing wish expressed by participants many times throughout the project: Visually impaired people want to take part in life again.

Research Report – insEYEght

Bridging technology and accessibility to empower the visually impaired.

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Abstract

In Germany, approximately 1.2 million people are considered blind or visually impaired (Institut der deutschen Wirtschaft Köln, 2023). Despite the availability of various assistive technologies – such as white canes, guide dogs, screen readers, and smart glasses (Deutscher Blinden- und Sehbehindertenverband e.V., 2025) – navigating daily life remains a significant challenge for many. These tools often lack the ability to provide real-time, context-aware support, particularly in dynamic or unfamiliar environments. This limitation underscores the need for more intuitive and responsive systems, forming the basis for the present study.

The research's primary purpose was to identify the main needs and challenges faced by blind and visually impaired individuals. The focus was set on exploring whether advancements in technology, such as Artificial Intelligence, could be used to enhance the quality of life of the target group. The study was narrowed down to close-range tasks, meaning activities requiring close vision, such as navigating public transport or reading text on signs.

In this study, we conducted interviews both online and in person. The participants were recruited through support groups, where we established initial contact and invited them to take part in the research. The interviews followed a semi-structured format, allowing for both guided questions and open-ended responses to gain deeper insights. The data collected was then transcribed and analyzed qualitatively using MAXQDA, a software tool for qualitative data analysis. This allowed for systematic coding and identification of key themes within the responses.

The collected data indicates that digital aids – particularly smartphone apps – are gaining the most traction due to their ability to integrate naturally into users' routines and address everyday challenges like grocery shopping or boarding the correct bus.

Background

Globally, millions of people live with visual impairments (Vision Loss Expert Group, 2017), including approximately 164,000 blind and 1,066,000 visually impaired individuals in Germany alone (In-

stitut der deutschen Wirtschaft Köln, 2023). These individuals rely on traditional mobility aids such as guide dogs and white canes, which, while effective, have limitations when navigating complex urban environments. Although assistive technologies, such as screen readers and navigation apps, have improved accessibility in certain contexts, there remains a significant gap in leveraging AI-powered wearable devices to enhance independent mobility and safety (Manirajee, L., Shariff, S. Q. H., & Rashid, S. M. M., 2024).

Thanks to rapid technological progress, including advances in the field of artificial intelligence (AI), blind individuals in some parts of the world can now be transported autonomously to their desired destinations. However even the daily journey to the supermarket remains a significant challenge for people with visual impairments (Bastola, A., Wang, H., Haeri Boroujeni, S. P., Brinkley, J., Moshayedi, A. J., & Razi, A., 2024). Despite the rise of AI-driven systems – such as autonomous vehicles, voice assistants, and smart home devices – the specific needs of blind and visually impaired individuals are often overlooked in mainstream technological development (Kacperski, C., Kutzner, F., & Vogel, T., 2023).

For blind individuals, safe and independent mobility remains a fundamental challenge. Crossing streets, avoiding obstacles, and navigating public transportation systems require constant attention and often external assistance. Wearable technologies, including smart glasses, haptic feedback devices, and AI-powered navigation tools, hold great promise for improving accessibility. Recent advancements in computer vision, machine learning, and sensor technologies have enabled real-time object recognition, obstacle detection, and route guidance tailored to the specific needs of visually impaired users. For example, AI-driven navigation systems can assist in identifying street crossings, locating buildings, and detecting moving obstacles, providing crucial feedback through auditory or haptic signals (Baig et al., 2024). A pilot project has also demonstrated the potential of AI-enhanced augmented reality devices – such as modified HoloLens headsets – to help visually impaired individuals recognize their surroundings and identify familiar faces (Brilli et al., 2024).

Nevertheless, challenges remain in optimizing these technologies for daily use. Issues such as accuracy, usability, affordability, and user acceptance must be addressed to ensure widespread adoption. In addition, ethical considerations – particularly concerning privacy in AI-powered visual recognition – must be carefully managed to protect users' rights and autonomy (Feichtenbeiner et al., 2022).

This research focused on identifying the gap that AI-powered aids could fill by examining the main challenges faced by blind and visually impaired individuals, as well as the limitations of current assistive devices. By engaging with experts and incorporating user feedback, we aimed to uncover unmet needs and to explore how AI-driven solutions could promote greater independence in a technology-driven world.

Goals and Methods

In our study, selecting a qualitative approach was fundamental due to the specific objectives we aimed to achieve. While quantitative research, with its characteristic large sample sizes, can deliver generalizable results and enable group comparisons, our study required a more nuanced understanding. The qualitative approach enabled us to grasp the complexity of the needs and challenges faced by blind and visually impaired individuals. It allowed us to incorporate factors such as the personality of participants, their situational contexts, and their direct responses into our analysis (Xiong X. et al., 2022). Our semi-structured interviews, characterized by open-ended questions, provided the necessary flexibility, allowing for the adaptation of inquiry based on participants' responses. This adaptable method could capture insights potentially lost in predetermined survey questions.

Research Question:

The qualitative approach, which focused on capturing a rich and detailed picture of visually impaired people's experiences, led us to our primary question. We were motivated to investigate: *"What are the most pressing issues and challenges visually impaired and blind people face daily that can be approached by AI assisted tools?"*

Sample
The sample size of 30 interviewees consists of visually impaired individuals across Germany (N=30) with varying degrees of visual impairment. There are 17 males and 13 females. The average age is 55.3, the minimum is 29 and the maximum is 86 (n=20). Five participants live in rural areas and 16 live in middle-sized or larger cities [>= 20.000 inhabitants] (n=21). Of the 30 visually impaired, 6 are blind, 13 are severely visually impaired / nearly blind and 8 are visually impaired (n=27). Nine participants have had reduced sight since their childhood and 16 subjects lost their sight after the age of 16 (n=25).

Study Structure
1. Preliminary Phase - First Contacts:
The study began with an initial outreach to the regional group of Pro Retina, a self-help organization dedicated to visually impaired individuals. This first contact served to gain an initial sense and understanding of the environment and circumstances in which visually impaired people navigate their daily lives today. The organization supports and advocates for better living conditions and research advancements for those affected. After initiating first contact with the leader of the regional group, we were invited to attend one of Pro Retina's monthly meetings. While no interviews were conducted during this visit, the interaction provided valuable initial insights into the existing challenges faced by individuals in the group. The participants of the meeting shared ideas on future possibilities but also expressed critical points of the existing aids. This was crucial to refining the study's focus and generating new ideas for the interview process. Additionally, we were able to establish important contacts for future interviews.

2. Additional Insights
To further enrich our understanding of the challenges visually impaired face as well as the already existing solutions, we attended the SightCity Fair held in Frankfurt. SightCity is the largest international fair dedicated to innovative aids for the blind and visually impaired. Our visit offered hands-on insights into existing solutions and ongoing research, and facilitated meaningful exchanges with experts, scientists, professors, and individuals directly affected by visual impairment. Participating in the fair proved crucial for improving the interview questions and understanding the broader context of the study. Additionally, it also facilitated the acquisition of valuable new contacts for future interviews.

3. Interview Design and Recruitment
Building on the insights gained from Pro Retina and the SightCity Fair, the interview questionnaire was finalized. To recruit participants, various organizations were contacted, in addition to the network established during the earlier phases of the project. The majority of the participants were obtained through Pro Retina. Other key organizations were the *Deutscher Blinden- und Sehbehindertenverband e.V., the Bayerischer Blinden- und Sehbehindertenbund e.V., and the Allgemeiner Blinden- und Sehbehindertenverband e.V. Berlin.*

In total, over 100 individuals expressed interest in participating in the study and 30 participants were selected yielding converging results, meaning that no new themes or insights emerged in the later stages of data collection. The selected participants were chosen randomly.

4. Conducting the Interviews
The interviews were structured to resemble a conversation rather than a formal survey. This approach allowed interviewees to elaborate on their experiences and offer insights beyond the scope of the prepared questions. Following an exploratory approach, our main objective with the chosen interview style was to create a comfortable and open setting for the interviewees.
Depending on the course of the conversation, additional questions might have been asked to explore specific topics in greater depth. This was particularly done when we felt that the interviewee had more to share than initially stated, or when new aspects emerged that, as non-affected individuals, we hadn't considered beforehand. This was precisely the value of conducting interviews, uncovering insights that go beyond our own perspective.

The data collection phase spanned two months and served as the foundation for subsequent analysis.

Materials

Category System
To design our interviews as well as planning the subsequent data analysis, we grounded our approach in Mayring's qualitative content analysis methods (Mayring, P., 2015). This approach provided us with a structured yet flexible framework. This structure ensured that, both data collection and interpretation, which were carried out by different team members, remained consistent, as it left less room for personal interpretation.

Our category system was developed to structure and analyze the interview data systematically. It included deductively derived categories, based on theoretical concepts, as well as inductively developed themes that emerged during the interviews to better reflect the data. The developed category system (see Table 1) was afterwards used for our qualitative content analysis. It provided a structured way to organize our interview data, which facilitated the interpretation. The themes and patterns of the interviews could easily be identified as various segments of text were assigned to defined categories. This allowed us to make meaningful comparisons between the interviews. In accordance with Mayring, this ensured that the analysis remained focused and analytically grounded.

The following table provides an overview of the final category system:

Main Category	Subcategory	Specific Aspect	Details
Demographic Data	Gender	–	–
	Age	–	–
	Employment Status	Full-time	–
		Part-time	–
	Living Situation	Alone	–
		Accompanied	–
	Place of Residence	Rural	–
		Urban	–
	Visual Impairment	Degree of Impairment	Description, visually impaired (low vision) or blind In accordance with WHO (World Health Organization: International Classification of Impairments, Disabilities, and Handicaps 1980; page 79)
		Congenital vs Acquired	–
Current Problem Areas	Private Space	Obstacles	–
		Information	–
	Public Space (Transportation)	Obstacles	–
		Information	–
	(Enclosed) Public Space	Obstacles	–
		Information	–
	Accidents	Obstacles	Occurence Rate, Severity, caused by Others vs Self-inflicted
Main Transportation	Private	Walking	Alone, With Assistance
		Car	–
		Bicycle	Alone, With Assistance
	Public	Local Transportation	Alone, With Assistance, Subdivided (Bus, Train)
		Long-distance Transportation	Alone, With Assistance, Subdivided (Bus, Train, Airplane)
Assistive Devices	Present (currently in use)	Traditional Assistive Devices (e.g. Cane)	Pros & Cons
		Innovative Smart Assistive Devices (e.g. Smart Cane)	Pros & Cons
		Digital Assistive Devices (purely software, e.g. BeMyEyes)	Pros & Cons
	Past (no longer in use)	Past Assistive Devices	Device, Reason for Purchase, Reason for Discontinuation
	Future (Desired of Aids)	Properties & Functionalities & Feedback Mechanism	Feedback (verbal, acoustic, vibration/haptic feedback, customizable [Yes/No])

Table 1: Category system

Recordings & Transcription

Before starting the interviews all the interviewees were asked for permission to record the conversation. Of the 30 interviews conducted, 24 were recorded using either a recording device or Zoom's built-in feature. The remaining six were documented through detailed notes due to technical limitations. The recordings were transcribed using the latest Whisper speech-to-text model. Whisper was selected for its swift ability to process large volumes of audio data. After the first automated transcription, each transcript was manually reviewed following Kuckartz's transcription guidelines to ensure correctness and consistency (Kuckartz, 2002). This step was crucial to correct transcription errors of the Whisper model. All recordings and contact information are stored until the project is finished in June 2025.

For the analysis, we began by using MAXQDA to code the interview transcripts. The coding process was guided by our predefined category system (see Table 1). This facilitated the identification of patterns across the interviews. To ensure consistency and reliability in our interpretation, each coded transcript was independently reviewed by a second team member. Any discrepancies were resolved through discussion and mutual consensus. Once the coding process was completed, the coded segments were exported from MAXQDA as an Excel file for further processing. In the next step, a Python script was used to clean the exported data by removing irrelevant elements such as timestamps, and merging fragmented segments. This preprocessing step improved the readability and usability of the data for subsequent synthesis. Afterward, the relevant coded text passages were manually reviewed. Key content was extracted from these passages and organized into a structured Google Sheet for further analysis.

Outcome and Discussion

The study classified assistive tools into three distinct categories: traditional, innovative/smart, and digital aids. Traditional tools comprised devices such as guide dogs, white canes, sunglasses, and handheld magnifiers. In contrast, smart tools encompass advanced devices like the OrCam, ultrasonic devices, bone-conduction headphones, and other interactive gadgets. Digital aids refer specifically to software-based tools – primarily smartphone applications – such as MyWayPro, the DB App, BeMyEyes, screen readers, and magnifier apps, which utilize the multifunctionality and widespread availability of modern smartphones.

Distribution of Aid Usage by Disability Category

As illustrated in Figure 1, the prevalence of aid types differs across disability groups. For individuals who are blind, traditional tools were the most common, followed by smart aids and digital tools. Among visually impaired participants, digital aids dominated usage. A similar trend was observed in the severely visually impaired / nearly blind category, where digital tools were again predominant (over 40%), succeeded by smart aids and traditional tools. Overall, digital tools emerged as the most frequently recorded category with 49 devices, compared to 37 traditional and 36 smart devices. This shift toward digital solutions is largely driven by the ubiquity and cost-effectiveness of smartphones, which all participants owned. Unlike traditional or smart devices that typically require specialized training or entail higher expenses, smartphones offer a versatile platform enriched with numerous assistive applications, making them a highly accessible and empowering option for visual support. The three different aid types will now be examined further.

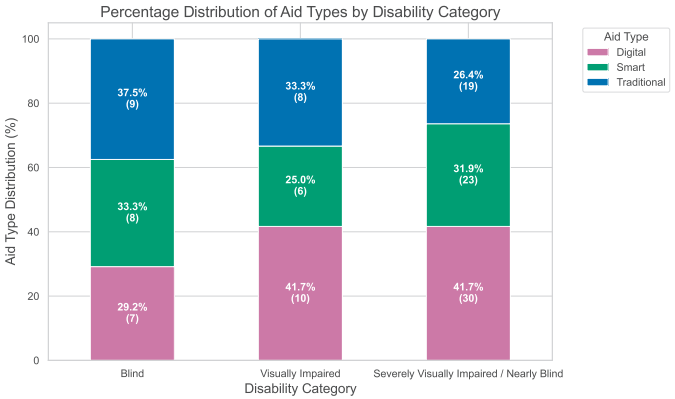

Figure 1: Percentage Distribution of Aid Types by Disability Category

Smart Aid Usage Patterns

Figure 2 compares the usage of smart aids across the three visual disability categories. The tools are grouped into five categories based on their primary functions. Reading tools support reading and magnifying text. Accessibility tools help users enjoy accessible audiovisual content. Communication tools offer real-time support and screen access. Navigation and orientation tools assist with spatial awareness and travel. Visual recognition tools identify surroundings and objects.

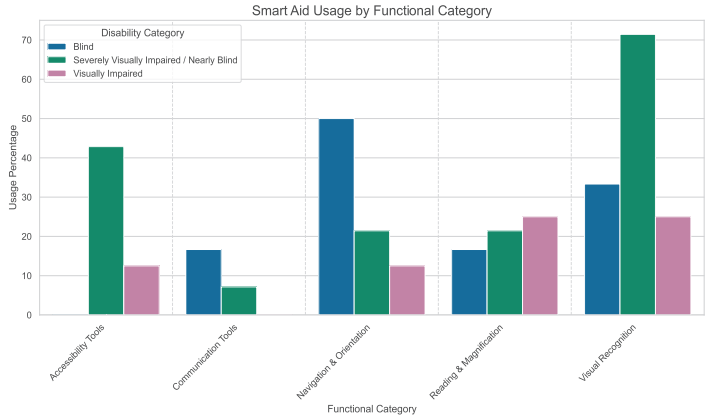

Figure 2: Comparison of Smart Aid Usage

The data reveal varied preferences that align with the severity of impairment. For example, the OrCam is predominantly used by the severely visually impaired / nearly blind group – with adoption rates exceeding 60%. Conversely, devices such as the vibration belt, ultrasonic device, and bone-conduction headphones are chiefly used by individuals who are blind. These findings highlight the necessity of aligning assistive technologies with the specific requirements of distinct user groups.

Digital Aid Usage Patterns

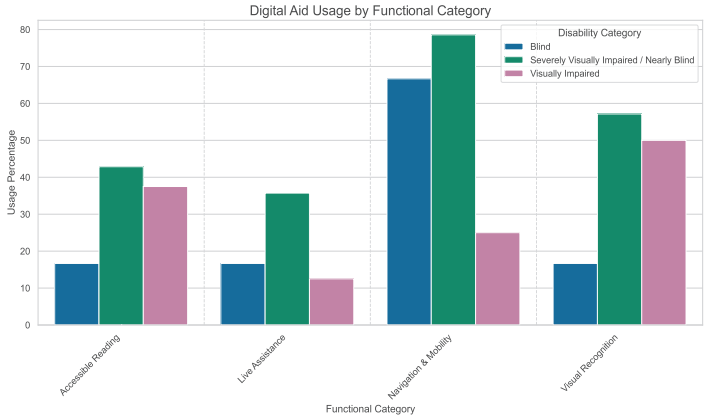

Figure 3: Comparison of Digital Aid Usage

Figure 3 presents an analysis of digital aid usage across disability categories, revealing distinct patterns based on visual impairment severity. The aids were categorized in the same way as the smart tools, except the Reading and Magnifying category, which is no longer included. Applications such as Be My Eyes, Screen Reader, and Google Maps are used consistently among all groups. Notably, these are all digital apps, highlighting the importance of smartphones for visually impaired people. Seeing AI is used most by severely visually impaired people, indicating it is most useful for this user group.

Traditional Aid Usage Patterns

In Figure 4, the usage of traditional aids is compared among blind, visually impaired, and severely visually impaired / nearly blind individuals. The white cane, though a longstanding tool, remains the most widely used traditional mobility aid today – especially among blind individuals (over 80%) and those who are severely visually impaired or nearly blind (around 78%) – underscoring its continued relevance and essential role in independent navigation. While blind participants showed a higher reliance on identification armbands, visually impaired individuals tended to favor sunglasses and magnifying glasses – with sunglasses usage reaching nearly 40%. Other aids, such as edge filter glasses, guide dogs, and standard glasses, were utilized less frequently across all groups, although magnifying glasses saw slightly higher use among the severely visually impaired. This distribution reinforces the enduring importance of traditional aids – especially the white cane – for

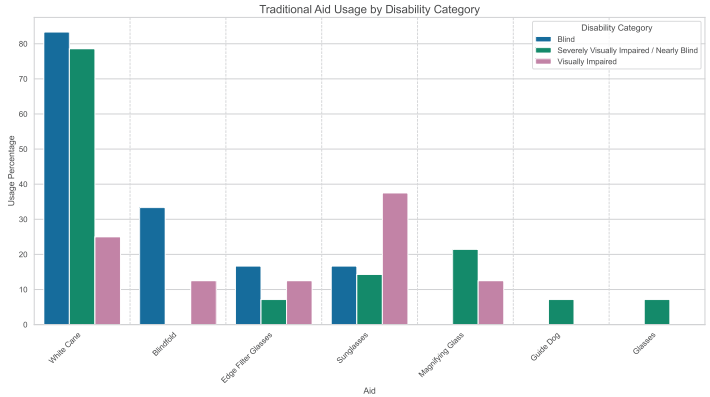

Figure 4: Comparison of Traditional Aid Usage

those with complete or near-complete vision loss, while individuals with partial vision loss often rely on devices that enhance existing visual capabilities.

Analysis of Reported Problems

Figure 5: Normalized Problem Count by Category (Information vs. Obstacles)

Figure 5 presents the average number of challenges per participant in each vision-loss category, divided into information-related issues and physical obstacles. Severely visually impaired or nearly blind users report the highest mean number of information challenges, followed by the visually impaired group, with blind participants reporting the fewest information-related problems. By contrast, obstacle‑related difficulties are most pronounced for blind users, while visually impaired and severely visually impaired participants encounter fewer physical barriers. These normalized results underscore that, although physical obstacles remain significant – especially for fully blind individuals – the greatest and most pervasive need lies in improving information accessibility, a need felt most acutely by those with intermediate vision loss.

Figure 6 offers a detailed breakdown of problem areas by disability category, illustrating how the severity of visual impairment shapes the types of challenges encountered. For blind participants, difficulties were most prevalent in closed space information and traffic obstacles, with traffic information issues also being notably significant. Those in the severely visually impaired / nearly blind group reported the highest concentration of challenges related to traffic information, underscoring the critical need for improved wayfinding and communication tools in dynamic, outdoor environments. Meanwhile, visually impaired individuals faced their most significant challenges with closed space information (over 30%) and traffic information (over 25%). Also, as visual impairment worsens, physical obstacles become increasingly problematic, peaking in frequency among blind participants. These patterns show that different levels of vision loss create distinct needs for accessing information and navigating environments, underscoring the importance of personalized, context-aware assistive technologies. As visual impairment becomes more severe, physical obstacles pose greater challenges, reaching their highest impact among participants who are blind.

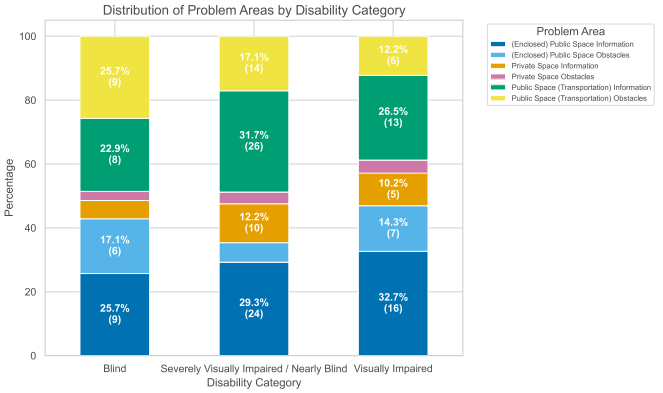

Figure 6: Distribution of Problem Areas by Disability Category

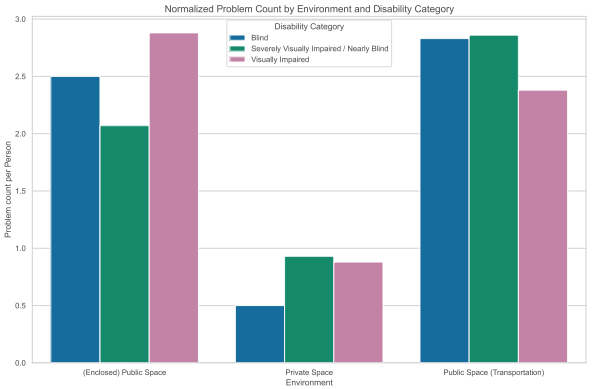

Figure 7: Normalized problem count by Disability Category and Environment

Criticism of currently available aids
In the past, participants used various assistive tools that they have since discontinued for several reasons, which will be discussed below.

One assistive device that saw moderate use in the past (n=3) was the vibration belt. However, participants reported that it lacked the precision needed for reliable directional guidance, making it impractical for everyday use. This perceived unreliability led to a lack of trust, ultimately contributing to the device falling out of use. Moreover, its optical appearance was often considered unaesthetic and embarrassing, further discouraging continued use.

Thirteen people currently use intelligent reading glasses as a current assistive device – yet most of these users voiced strong criticism and now scarcely use them. They found smartphones to be a more effective solution, thanks to faster operation and considerably longer battery life. In practice, the intelligent reading glasses often fell short of expectations in terms of reliability and ease of use.

A third assistive tool previously used by some participants (n=3) was edge filter glasses, designed to enhance contrast by filtering specific wavelengths of light. However, their usefulness was limited to certain conditions, and many participants stopped using them due to their ineffectiveness in variable lighting. In low-light environments, for example, the glasses offered little benefit, as there wasn't enough contrast to enhance.

Wishes for Future Assistive Tools
During our interviews, the blind and visually impaired participants expressed clear preferences regarding future technologies. The priority was less on complex devices and more on practical tools combining multiple functionalities that could simplify daily life, provide greater safety, and promote independence. Participants described various scenarios – from navigating public spaces to locating misplaced objects – that illustrate how appropriate technological support could contribute to greater autonomy. Below, we present the aspects identified by participants as particularly relevant.

Navigation and Orientation
Our study showed that everyday navigation was the top priority for all visually impaired participants. They desire a device that functions like a reliable companion, providing precise information about the immediate surroundings, a pedestrian crossing, a dangerous intersection or orientation in big open places. Additionally, the need for timely real-time warnings such as "Caution, a car is approaching from the left" was frequently mentioned. This goes beyond simple directions, it's about a fundamental sense of security.

Obstacle and Object Recognition
It also became apparent that obstacle detection represented another crucial priority. Participants recounted regular challenges with hazards such as discarded e-scooters on walkways, temporary construction barriers, or low-hanging branch obstacles that conventional assistive tools like white canes frequently fail to detect.

Beyond simple hazard avoidance, participants showed significant interest in an "object finder" functionality, a tool to help locate misplaced everyday items such as keys or remote controls.

Everyday Assistance
Our study revealed significant challenges with daily activities. Participants desired technology that provides immediate audio information of signs or documents, eliminating the need to request assistance. Shopping emerged as particularly problematic, with product identification causing frequent uncertainty. The core desire is to reduce anxiety in seemingly minor moments, finding addresses or selecting items from shelves, and make these tasks more manageable.

Feedback Preferences
Three different feedback channels were considered: haptic, auditory, and verbal alerts. Haptic feedback is primarily used for warnings, with the intensity encoding the level of danger. Auditory feedback consists of short alerts designed to convey information quickly and effectively. A strong preference was expressed for a modular approach, allowing the system to adapt to different situations and individual preferences. For example, vibration-based feedback proves particularly useful in noisy environments where auditory alerts might be difficult to perceive or could impose a way of distracting the user in dangerous situations, whereas verbal feedback can be advantageous when precise localization of an object is required. Additionally, combining multiple feedback channels could further enhance the overall effectiveness of the system.

Discussion

This study shows that digital tools, especially smartphone apps (see Figure 1), are now the most popular aids among visually impaired people, because of their seamless integration into daily life, affordability and many built-in features like VoiceOver. In simple terms, while guide dogs and white canes remain useful, modern digital devices help users with everyday challenges like navigating busy streets and detecting obstacles or reading out text.

The study involved 30 visually impaired individuals who shared their experiences in interviews. The study used a clear qualitative content analysis method based on a category system to group common themes from these interviews. Participants explained their daily struggles like crossing streets, avoiding hazards, and performing close-range tasks such as reading signs.

Additionally, most participants owned Apple products due to their comprehensive accessibility features, such as VoiceOver, magnification tools, and customizable display settings, which are seamlessly integrated into the iOS ecosystem. The reliability and ease of use of these built-in features make Apple devices particularly attractive to visually impaired users, further contributing to the widespread adoption of digital tools. Other smartphone manufacturers are catching up (Leigh, 2017). As technology continues to evolve, digital solutions are likely to play an even greater role in enhancing accessibility and independence for individuals with visual impairments.

Inconsistencies regarding the protocolation and interpretation of the interview arose due to 8 different people from different academic backgrounds and age groups conducting, transcribing and interpreting the interviews. Thus, demographic data wasn't always recorded and only 24 interviews were transcribed word-by-word while 6 were documented by detailed note taking.

Considering the study size of 30 people, the distribution of impairments within the spectrum was unequally distributed with 21,4% of all participants being completely blind, 28,6% having a significant amount of eyesight left and 50% being almost completely blind.

Given the average age of 55.3 years, the results primarily reflect the opinions, values, and experiences of an older demographic, which may introduce bias. However, since the average age of visually impaired individuals is generally high (Berufsverband der Augenärzte Deutschlands e.V., n.d.), this bias is difficult to avoid, but still influences the results since older people tend to be more sceptical of modern technologies.

In conclusion, while the study highlights the growing importance of digital tools for visually impaired individuals, more research is needed to create devices that are practical and reliable. By combining the best of all available technologies, future assistive tools could make daily life much easier and safer for those with visual impairments.

Summary and Future Goals

The conducted study offered an analysis of the challenges facing blind and visually impaired individuals, with a specific focus on near-work activities such as traveling by public transport. The study was grounded on 30 face-to-face and online semi-structured interviews, with participants distributed throughout Germany. The qualitative data obtained were coded using MAXQDA, allowing systematic coding and determination of salient themes regarding common challenges faced by the target population.

Key findings of the study were concentrated on the use of assistive devices. Technological devices, and in this case mainly smartphone applications, dominated the field as they were cost-effective and convenient to integrate into daily activities. Despite the superiority of the technology, traditional devices like white canes or guide dogs still provide value to the lives of the visually impaired. This suggests there may be a gap that could be addressed with AI-powered aids.

A primary area for improvement was navigation and orientation within complex urban environments, which remains a significant barrier for individuals who are blind. "Direct attention" was also highlighted in areas such as object and obstacle detection, as well as assistance with tasks like shopping – primarily due to the anxiety and uncertainty these situations can cause. These areas clearly represent opportunities where AI-based tools could provide effective solutions.

Prospectively, developing a functional prototype that leverages the capabilities of Artificial Intelligence could significantly address the

challenges faced by the visually impaired. This prototype should ideally integrate the strengths of traditional, digital, and intelligent tools into a user-friendly solution tailored to their needs.

The initial form factor for deployment is likely to be a smartphone application, given the widespread familiarity and usage of smartphones among the target group. Over time, this may be extended through integration with an AI-powered wearable device to further enhance functionality and user experience. The prototype should prioritize improved navigation by providing precise environmental information, timely alerts for potential hazards, and reliable object and obstacle recognition. Safety-critical features such as real-time object detection, obstacle avoidance, and tailored route guidance are essential to ensure the device acts as a dependable companion that maximizes user safety.

Interview results further emphasize the importance of a modular feedback system that adapts to varying real-world scenarios. Instead of a one-size-fits-all approach, the prototype should combine haptic, auditory, and verbal cues, dynamically adjusting based on context. For example, in noisy environments where auditory feedback may be ineffective, the system could switch to haptic notifications, and vice versa. This flexible feedback mechanism is crucial to maintaining effective communication and enhancing the overall user experience.

Ultimately, such a device would represent a major leap toward a more inclusive, technology-driven society – one that empowers visually impaired individuals with greater independence and quality of life. The development of this prototype is not just a technical milestone, but a step toward realizing a broader, more equitable future.

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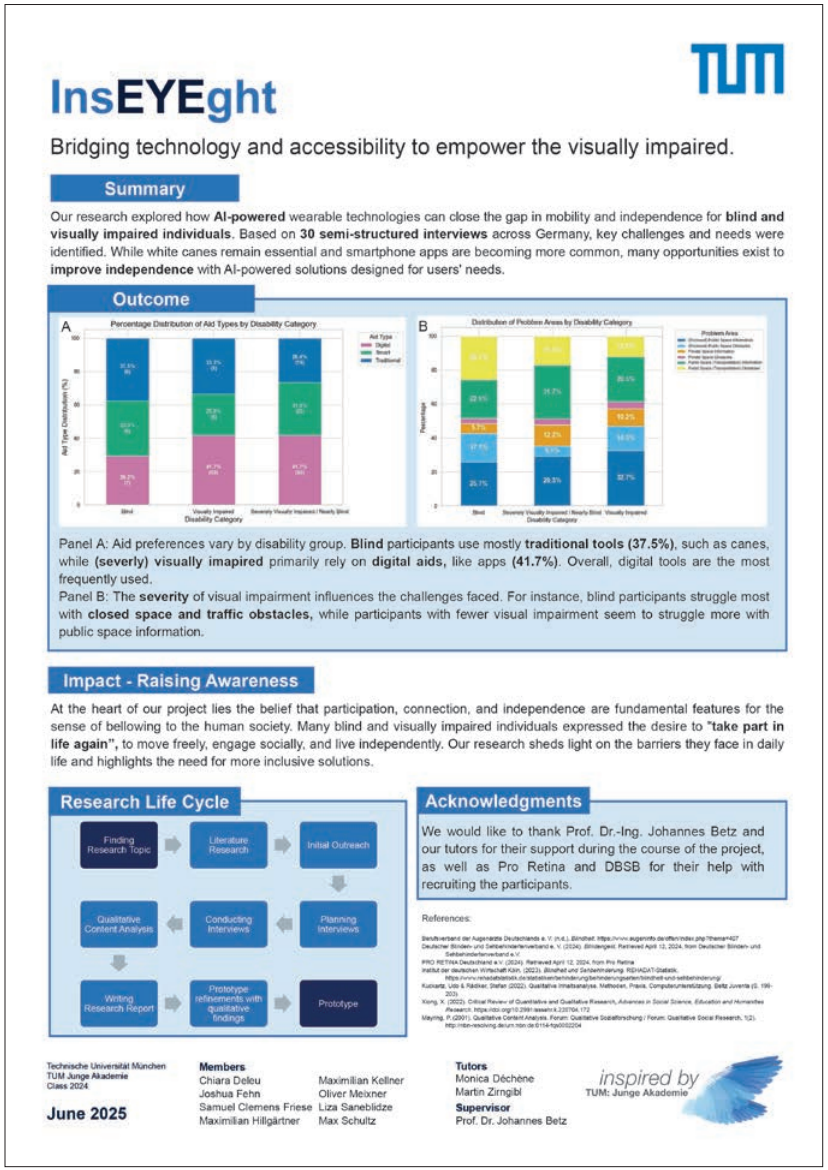
Process description



InsEYEght

Bridging technology and accessibility to empower the visually impaired.

Summary

Our research explored how **AI-powered** wearable technologies can close the gap in mobility and independence for **blind and visually impaired individuals**. Based on **30 semi-structured interviews** across Germany, key challenges and needs were identified. While white canes remain essential and smartphone apps are becoming more common, many opportunities exist to **improve independence** with AI-powered solutions designed for users' needs.

Outcome

Panel A: Aid preferences vary by disability group. **Blind** participants use mostly **traditional tools (37.5%)**, such as canes, while **(severly) visually imapired** primarily rely on **digital aids,** like apps **(41.7%)**. Overall, digital tools are the most frequently used.
Panel B: The **severity** of visual impairment influences the challenges faced. For instance, blind participants struggle most with **closed space and traffic obstacles,** while participants with fewer visual impairment seem to struggle more with public space information.

Impact - Raising Awareness

At the heart of our project lies the belief that participation, connection, and independence are fundamental features for the sense of bellowing to the human society. Many blind and visually impaired individuals expressed the desire to **"take part in life again"**, to move freely, engage socially, and live independently. Our research sheds light on the barriers they face in daily life and highlights the need for more inclusive solutions.

Research Life Cycle

Acknowledgments

We would like to thank Prof. Dr.-Ing. Johannes Betz and our tutors for their support during the course of the project, as well as Pro Retina and DBSB for their help with recruiting the participants.

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Supervisor
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Our initial idea was to use AI to increase efficiency in the healthcare sector – under the team name EfficiAID. We quickly realized that legal and structural complexity limited real impact. A second idea, an AI chatbot to replace GP visits, seemed feasible due to clear diagnostic criteria but was dismissed as similar solutions already exist.

A breakthrough came with the idea of AI-powered smart glasses for visually impaired users. This raised essential questions: What are the hardware and software requirements? What are the real challenges users face in everyday environments – private spaces, traffic, public buildings? What accidents still happen, which aids are used, and what criticism exists?

To answer these, we pivoted to our final idea and renamed the team InsEYEght. Our focus shifted to user research through semi-structured interviews. This covered literature reviews, a flexible questionnaire, and contact with several self-help groups. Interviews were conducted, transcribed, and systematically analyzed. The resulting insights revealed real-world needs that now shape our project.

Outlook: These insights form the foundation for future prototype development, ensuring solutions are rooted in actual user challenges.

Self-Reflection insEYEght

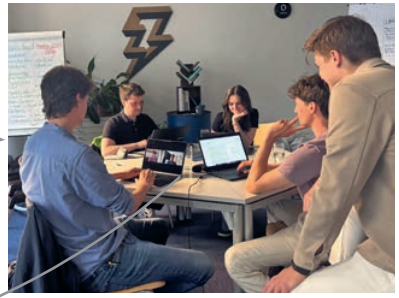
Our Team-Journey

Johannes
joined :)

Monica & Martin
joined :)

Lab Tour by Johannes

Visiting the SightCity in Frankfurt



Planning Interviews

Data evaluation Workshop
by Monica

Final Team-Building

Research Report **meinung**

What makes us human? One answer is ethics and morality. The TUMJA project meinung analyses moral stances in text. It builds upon an existing mapping of words to their moral meanings, and combines this with the large language model BERT. As such, meinung improves existing methods of measuring morality by extending the scope of applicable words, i.e. moral vectors can now be calculated for almost any word – which also improves performance for short texts. Additionally, the approach of meinung allows differentiating identical words in different contexts and thus different meanings.

Team	Viktoria Obermeier Yunqing Wang Maximilian Frank Tim Knothe Julius Mankau Nikola Martinov Staykov Christian Nix
Tutors	Eva-Madeleine Schmidt Stefan Engels
Supervisor	Prof. Dr. Claudia Klüppelberg Prof. Dr. Martin Werner

Preface by the Supervisors

Prof. Dr. Claudia Klüppelberg und Prof. Dr. Martin Werner

Information provided by newspaper texts expresses and influences moral perceptions of our society. Our team "meinung" had the ambition to understand possible changes in moral perceptions over the years and chose environmental news as one prominent example. When natural disasters like floods, heatwaves, earthquakes, and hurricanes strike, the media report immediately. Moreover, questions are raised about responsibility and blame. Could the disaster have been prevented, was the response of government and disasters services adequate? This way, often, a natural disaster leads to moral questions and to discussions about climate change, including accusations of neglect of sustainability issues by politicians.

The team members drew on different scientific methods to study word connotations by building a metric based on counts of negative and positive words. Acknowledging the complexity of the problem of assessing moral perceptions within society, our team used five different base criteria: authority, care, fairness, loyalty and sanctity. Their study also incorporated considerations of context awareness as well as non-explicit context. The fact that language changes naturally over time is also taken into account. An algorithm has been designed to implement these issues for analyzing moral connotations in texts and compared favorably to the extended Moral Foundations Dictionary.

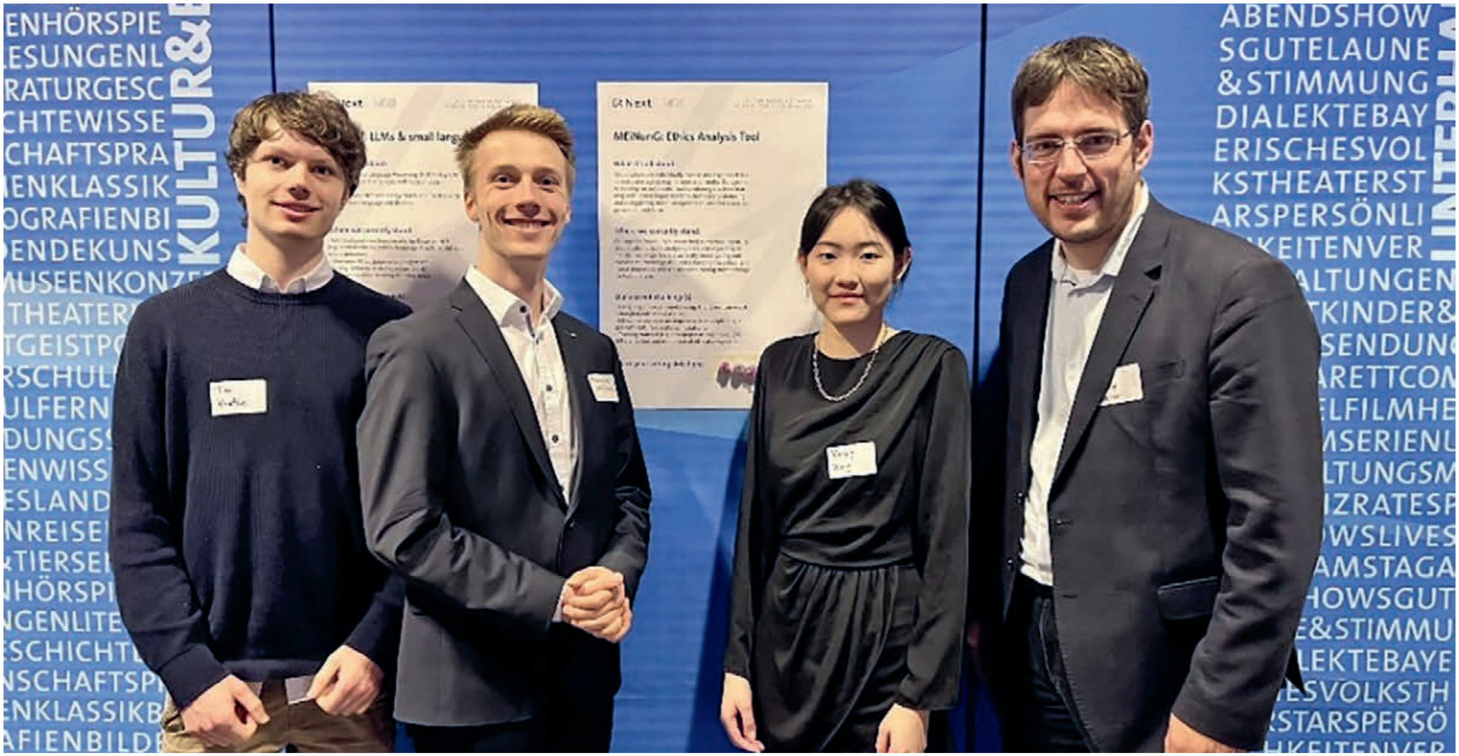
The team succeeded in a demanding project of interdisciplinary research at the intersection of sociological, philological and computer science contributing to the discussion of the ethical foundations of our democracy.

Beyond the technical achievements, what stood out most was the spirit of cooperation and the shared vision within the team. Despite different backgrounds and skills, they were united by a common goal, which led to valuable project results.

As supervisors, we had the privilege of observing a team of young students developing from highly motivated singletons in different study programs into a joint research team, whose interdisciplinary members brought in their diverse personalities and disciplinary strengths to successfully conclude a unique and socially important project within the given deadline. Each member brought unique perspectives and expertise to address the challenges of complex text- searches in answering questions about how our society changes moral perceptions.

One of the best TUMJA moments was the invitation of team members to the BR Forum "AI for Media: Science meets Journalism" organized by Bavarian Public Broadcasting Service (see photo). In this meetup, they presented their initial results and got into discussion with practitioners from the press.

As supervisors of the team, we are proud of you and all your achievements. Working with you has always been a pleasure. ■


MEINunG: Ethics Analysis Tool

Can We Measure Morality?

The TUMJA research project *meinung* wants to enhance the current methods of morally analyzing text. But why is moral analysis a very relevant topic – if not crucial for democracy? Can we really push moral analysis beyond the theoretical analysis of dry text? Yes, we can. Because text is not just a form of expressing thoughts. Especially with newspapers, text actually becomes a mirror of society.

Floods, heatwaves, earthquakes, and hurricanes – natural disasters seem to be occurring with increasing frequency and severity. When disasters like these strike, the media responds swiftly, often becoming the lens through which the public experiences the chaos and aftermath. Headlines flash across news channels, websites, and social media, capturing not only the scale of the destruction but also the stories of those affected. While images of flooded streets, submerged homes, and displaced families dominate the front pages, there's often another narrative at play – one that extends beyond the immediate devastation. This narrative is about morality, responsibility, and blame: Who is at fault for the disaster's impact? Could it have been prevented? And what do these events reveal about our societies, our governments, and the way we treat our planet?

The ways these questions are framed in the media can shape public perception dramatically. In the United States, for instance, the response to Katrina was as much about the failure of federal relief efforts as it was about the hurricane itself. Even questions of race, class, and inequality surfaced, turning a natural disaster into a moral and political reckoning. Meanwhile, in Europe, coverage of extreme weather events often shifts quickly to debates over climate change, sustainability, and the collective responsibility of humanity for the increasingly volatile environment.

As we can see, news media bear a great responsibility in society, forming opinions and ultimately having an effect on political decisions. One thing which mainly influences how the news is perceived in the media is which words have been used – and we need to consider not only the words themselves, but also the contexts into which they are placed as well as their target audience. Unfortunately, many newspapers create captivating headlines to attract a large audience – at the cost of neutrality. So, it is essential to measure how words have been used in a newspaper article to increase transparency, which is quite important for a working democracy.

Word Connotations: There is a big difference in using words and phrases with similar meanings but different connotations. Speaking of environmental topics, you could describe agricultural farming as "a cultivation of nature to maximize the growing of food" – or, by contrast, "the occupation of natural space to satisfy human greed." When analyzing such varying connotations, and whether a news article expresses a positive or a negative viewpoint, one could easily assign each word a number on a scale from positive (e.g., 1) to negative (e.g., -1), and sum the values up. For example, in the positive example above, we have "cultivation" and "maximize" – two positive words, i.e., score +2. The negative example contains "occupation" and "greed" – two negative words,

i.e., score -2. However, a balanced sentence or article would yield a number near zero, like “Agriculture is a cultivation of nature to maximize the growing of food. However, in the context of rainforests it may seem less negative to say it is rather an occupation of natural space to satisfy human greed” – yielding a score of 0. By using this metric now, one could not only classify news articles into positive or negative, but also observe the newspapers’ orientation over time. In fact, there already exists such a score, called the extended Moral Foundation Dictionary. As measuring morality and word connotations is quite complex, it does not have just one dimension as in the examples above (i.e., negative to positive), but actually five different dimensions: authority, care, fairness, loyalty, and sanctity.

Context Awareness: One downside of the above-described method is that it is unaware of any context. For example, the expression “love”, as related to parents, has quite a different meaning than “love” as related to ice cream – even though it is the same word. That’s where natural language processing comes into play: It translates all words into a mathematical construct called vectors – you can think of them as virtual words. So, in very simplified form, a sentence like “I love ice cream” is turned into “I love-as-in-like ice cream“ and “I love my parents” is turned into “I love-as-in-relations my parents.” Now, you can compare the words again, because “love-as-in-like” is a different word than “love-as-in-relations.” In fact, natural language processing doesn’t compare words like we humans do, but rather using the aforementioned vectors and numbers.

Non-explicit Context: However, context alone is not sufficient either. Even expressions “I like trees” or “I love my parents” have very different meanings across cultures. For example, in Eastern countries, parents enjoy a much greater authority beyond a child’s legal age than in Western countries. People in the mid-latitudes have a very different understanding of the robustness of trees than in African countries. For example, a robust tree in Germany is associated with an oak, whereas in Africa it is mainly associated with robustness against drought.

Time-Factor: Even if you account for all aforementioned factors during the analysis of the connotations in news articles – language still changes over time. The German word “geil” (colloquial for awesome) had a very different meaning a few decades ago: horny. And language now seems to change faster than before. For analyzing moral connotations in texts, it is thus almost essential to find an automated algorithm, so that the analysis can be conducted faster, more efficiently, and – most importantly – neutrally.

This is in essence what the TUMJA research project *meinung* is about: Enhancing methods of moral analysis in text. In this, we aim to contribute to existing research at the intersection of sociological and philological research as well as computer science. Moreover, measuring morality facilitates the assessment of opinionating articles and thus serves as a factor of transparency – ultimately an important prerequisite for democracy. ■

Research Report – meinung

Enhancing the extended Moral Foundation Dictionary with BERT

Table of contents:

Introduction

Moral values, as a product of human civilization and communal living, continually evolve and adapt along with changes in the spirit of the times. Most research examining moral content in text has been based on the practical application of moral foundations theory [1]. This suggests that individuals across different cultures and societies share five innate and universal moral foundations, each with their positive/negative poles as virtue and vice: care/harm (incl. sympathy, compassion, and nurturance), fairness/cheating, loyalty/betrayal, authority/subversion (involves concerns about traditions and maintaining social order), and sanctity/degradation (involves moral disgust and spiritual concerns related to the body). Using moral foundations theory as a framework, dictionary-based approaches have been developed to analyze moral content. The methods used therein focus on identifying the frequency at which keywords related to moral foundations appear in a text [2].

History of Moral Measuring

Graham et al. [3] created the first dictionary based on moral foundations theory. This dictionary was constructed through the manual selection of words from thesauruses and conversations with colleagues, which were chosen to represent the upholding or violation of specific moral foundations. After some research, the Moral Foundations Dictionary (MFD) [4] was first implemented to study differences in moral language, for example in religious texts [3]. In essence, the MFD maps words with moral values to one or more moral foundations, but most often only one.

While the MFD provides a straightforward, word-count-based method for extracting moral content from text, several concerns [5–7] have been raised regarding its theoretical validity, practical utility, and scope. Hopp et al. [8] summarized these concerns into three categories:

Validity and Generalizability. The MFD is constructed using lists of moral words, which were deliberately selected by a small group of experts [3]. This approach raises concerns about the dictionary's ability to accurately capture intuitive moral processes in the general population, and thus invites criticism of its validity.

Categorization Limitations. The MFD and similar tools rely on a binary approach, where each word is assigned fully to a moral foundation – but this clearly does not allow for any scalar differentiation (e.g. slightly fair). This rigid classification constrains the dictionary's ability to reflect the natural variation in moral information and its contextual meanings across diverse situations.

Simplified Representation. The methods used for the MFD conceptualize text as so-called "bags of words" [9], which significantly limits their ability to capture the relational structure of moral acts, such as identifying the actors involved, the nature of the actions, and the underlying reasons for their occurrence.

To address these limitations, Hopp et al. [8] developed the extended moral foundations dictionary (eMFD). In contrast to previous approaches, the creation of the eMFD involved a web-based, hybrid content annotation platform, known as the Moral Narrative Analyzer (MoNA). Annotators were instructed to identify five predefined moral foundations within news articles, which were sourced from major media outlets. Prior to annotation, the texts were preprocessed through tokenization, stop-word removal, and part-of-speech tagging, which is a form of tagging words with their grammatical function (e.g. nouns, verbs, …).

A total of 2995 articles were annotated, and words or phrases were assigned probabilities for each moral foundation based on annotation frequency. So, words were not only assigned to one or more moral foundations, but also had different degrees of intensity in each moral foundation. This intensity is measured on continuous scales between -1 and +1, e.g. +1 for care, -1 for harm, 0.6 for rather care, and so on. To ensure reliability, lexical items were filtered and retained only if they occurred multiple times across different annotators and contexts. Additionally, sentiment analysis using VADER (Valence Aware Dictionary and sEntiment Reasoner) was employed to classify words into "virtue" or "vice" categories, thereby capturing their moral valence.

Besides creating the dictionary, Hopp et al. also validated it on a newspaper articles dataset. The accompanied Python library eMFDScore enables moral analysis through bag-of-words and syntactic dependency parsing methods. The eMFD was validated through statistical tests, comparing it to previous dictionaries (like MFD 2.0). With a total of 3270 words, the eMFD provides a robust tool for analyzing moral connotations in text and serves as a base for further research.

Research Questions

One flaw with static word lists is that any change of meaning due to different contexts is normally not reflected in the measures for each moral foundation. For example, the word "love" in "I love ice cream" has a different meaning than in "I love my parents." Despite the eMFD's attempt to include contextuality in calculating moral connotations of words, the moral values are combined into a single moral vector for each word. This lack of differentiation also applies to the eMFD. Thus, we investigate how the eMFD can be improved to account for different meanings of the same words in different contexts (RQ1).

Second, as the moral foundation dictionary was created statically, and language is constantly changing, a static version of the eMFD might not reflect all words with a moral connotation. Thus, we investigate how the eMFD can be extended to measure moral connotations of words which are currently not within the eMFD (RQ2). This enables moral measurement of words beyond its limits. Summarizing the above, our research questions are as follows:

- *RQ1:* How can the eMFD be improved to also account for different meanings of words resulting from different contexts?
- *RQ2:* How can the eMFD be extended to measure moral connotations of words currently not within the eMFD?

To answer these questions, we combine the eMFD with a large-language model, which models a superset of the words in the eMFD. In this way we can generalize moral dimensions to other words which are not mapped to a moral vector yet.

Our moral language model allows to capture differences in semantic meanings of words by taking their context into account. This is crucial for accurate moral and semantic analysis. Additionally, our

approach is not based on a static dictionary but effectively allows for modularly extending the eMFD based on the used large-language model. And lastly, we validated our model by using difference-in-difference comparisons with the eMFD. Validation was conducted with regard to alignment with the eMFD, generalizability to words not contained in the eMFD and whether our model performs better with short texts, like those that prevail on social media. As such, we contribute an important milestone to context-aware moral measuring, which is relevant in various fields of science such as fake-news detection or neutrality analysis of text.

Related Work

There is a range of existing research related to our work. In the following, we provide a brief overview of such research.

Applications

Sagi et al. [10] performed a moral analysis on tweets connected to the U.S. government shutdown in 2013. Their main focus were the differences in moral stances between intra-community and inter-community retweets on that topic. The research also took into account how much users interacted with the actual content – besides the moral logic. Interestingly, there was a significant effect: Content was emphasized more than moral rhetoric.

Similarly, Roy et al. [11] analyzed moral sentiment in U.S. politicians' tweets about two controversial topics. The research shows a significant difference between political parties.

From both research projects, we can see that differences in moral stances can indeed be measured between groups. This is a prerequisite for verifying our research.

MFD Extensions

Rezapour et al. [12] extended the MFD [4] with a manual process involving humans. Besides that, they also applied their enhanced MFD on natural language processing tasks to test its usefulness for measuring social effects. While validating the enhanced MFD with language models, they were not used in the extension process itself. So, in contrast to our research, they do not account for different meanings of the same words in different contexts.

Due to language limitations, Cao et al. [13] created their own moral foundation dictionary by adapting moral foundation theory to the Chinese language domain. Besides manual semantic annotation, they complemented their approach with large-language models to extend their dictionary. However, their results are limited to Chinese comments on Weibo. We expect different results for English large-language models which include more versatile input sources than short-text comments.

Egorov et al. [14] proposed an orthogonal dimension to the moral foundation theory. They extended the existing five foundations each with four different sensitivities: victim sensitivity, observer sensitivity, beneficiary sensitivity, and perpetrator sensitivity. These should give a better differentiation for each moral foundation, because the perception of morality depends on each perspective.

Sagi et al. [7] use a keyword-based approach to apply the eMFD to any kind of text of a specific topic domain. This enables filtering out moral values of different topics contained in the same text. Before that, this had added additional noise to moral measurements. However, they still use the static dictionary approach of the eMFD – so while their approach discards off-topic statements, they still do not include contextuality into their measurements.

More akin to our research, Nguyen et al. [15] fine-tuned a large-language model for analyzing moral stances in newspaper articles. This model, called Mformer, was found to outperform existing approaches of moral measurement. While their language model is applicable to several text domains, they estimate moral connotations directly via the model – instead of focusing on extending the eMFD. Thus, we also use different approaches for validation than the ones used by Nguyen et al.

Unfortunately, many approaches involve manual human annotations. This doesn't scale to analyzing large text corpora. Another limitation of human-annotated moral models is noise introduced by the annotations [16]. We therefore focus on an approach which does not involve human annotation.

Methods

One of the most widely used methods to evaluate texts using the eMFD utilizes a method commonly known as bag-of-words (BoW) [8]. The BoW method counts the occurrence of words, which also have a moral vector in the eMFD. The remaining frequencies are then combined with the words' scores in the eMFD [8]. One limita-

tion of this approach is that each word in the dictionary contributes fixed moral values, regardless of its contextual usage. This context-insensitivity can lead to misinterpretation, as already noted with “love” as with ice cream or parents. We propose an approach to overcome this limitation and include context when analyzing words regarding their moral connotation.

Overview

To add contextual understanding to our moral model, we decided to combine the eMFD with a context-aware large-language model. For this, the context-aware BERT model (Bidirectional Encoder Representations from Transformers) [17] was a promising choice. BERT is a pre-trained transformer model for natural language and has found wide adoption due to its ease of use [18]. Specifically, it is aimed at generating bidirectional context-aware vector representations (i.e. embeddings) for text tokens (i.e. word fragments) [18]. So each vector of a word (i.e. embedding) uniquely codifies a certain meaning of this word. Other word vectorization models, like word2vec [19] or GloVe [20], are context-free and thus lack an essential property for our use.

First, we use the encoder of BERT to translate a sequence of tokens (i.e. word fragments) to a latent space, i.e. a high-dimensional vector space, which encodes the meaning of tokens. When using all words in a text for moral analysis, there may be a lot of noise. To isolate meaningful context-sensitive, moral directions and thus filter out noise, we reduce the amount of dimensions of the BERT latent space. This is done by creating a linear projection of the latent embedding space using singular value decomposition (SVD) [21]. During inference, token embeddings are projected into this reduced vector space to enhance model performance, following the approach of Brunton and Katz [22]. The number of dimensions of the projection is thresholded based on the method described by Donoho and Gavish [23]. We fixed the threshold at 100 for subsequent evaluations, which is the default value for SVD. Despite our resolution being quite low (reducing 768 dimensions from BERT [17] to 100 dimensions), this proved to be sufficient for our task – especially because we were only interested in five moral dimensions.

We then apply multiple linear regressions [24] to map the reduced embedding vectors to moral vectors for each word and thus decompose the context-free moral vectors from the eMFD into each of one or more context-aware versions. The regressions are modelled from the existing moral vectors in the eMFD. After calculating the moral vectors of individual words, the overall moral profile of a text is computed by averaging the individual word-level scores. For comparisons using the bag-of-words (BoW) method, the word-level scores were averaged, weighted by word frequency. Using the fitted regression models also for inference enables the consistent mapping of any contextualized BERT embedding to a moral vector.

Figure 1 visualizes the architecture of our approach. It also depicts which components are mainly responsible for context-awareness as well as generalizability/extendability to words currently not within the eMFD.

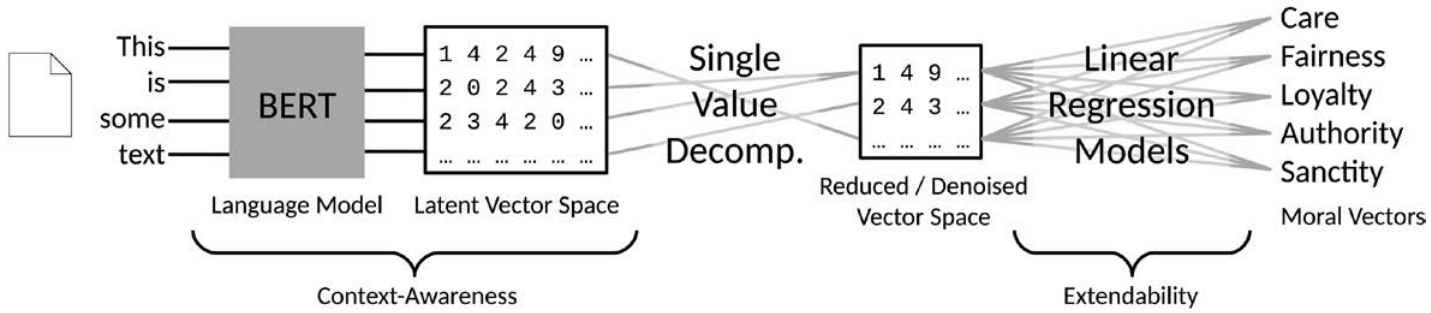


Figure 1: Model Architecture

BERT Word Embeddings
BERT allows for being fine-tuned by adding an additional layer, without having to train a full transformer model. Our model builds upon the hypothesis that the dimensions in BERT for representing words also encode moral connotations – even if not directly as moral vectors, but implicit as a linear combination of other vectors in the latent or reduced space. As we see in subsection 4.2, this hypothesis proves to be true. The implicit moral connotations are then extracted with multiple linear regressions using the ordinary least squares method [24].

To generate a context-aware embedding (i.e. vector) for each word of a text, we first frame the text between the [CLS] and [SEP] tokens. This instructs BERT to classify text [17]. The framed text is then tokenized using the pre-trained bert-base-uncased tokenizer1. The tokens are converted to token IDs and an attention mask considering all tokens is generated. Importantly, the BERT model can only handle a maximum of 512 tokens. Thus, we have to truncate the tokenized sequence to fit this restriction. Finally, the token IDs and attention mask are given to the pre-trained bert-base-uncased model. The BERT model is configured to return all hidden representations, so we can add the aforementioned fine-tuning layers.

Because the tokenizer might split individual words into multiple tokens so that each have a separate embedding, we have to aggregate these into a single embedding (i.e. vector) representing the combined word. This is achieved by averaging the moral scores of all tokens from each moral dimension, which together represent a single word. In other words, we take the average of a word's token embeddings to calculate the overall word embedding. As a result, the construction returns a list of tuples with each the word (as string) and a tensor, which contains a word's context-aware embedding (i.e. vector) for each of BERT's hidden states.

Validation
As we can see above, our approach effectively extends the eMFD beyond the range of its contained words. When comparing our model with the eMFD though, we have to ensure the same baseline with the eMFD. This means that we have to discard all words which are not contained in the eMFD from calculating the moral vector of the overall text. At the same time, we still would like to account for slight differences in moral connotations due to the words' context – which effectively is our improvement over the eMFD. To give an example, the moral vector of the following sentence is to be calculated: I love my parents. "I" and "my" may not occur in the eMFD – so we cannot compare our moral vector to the eMFD's vector for these words. However, due to exactly these words, there might be a slight difference in the moral vectors of "love" and "parents", because in our model these words are embedded in a different context. To account for this problem, we filter out words from calculating the moral vector without removing their context as follows.

As described in subsection 3.2, the words, for which one calculates the moral vectors, are first encoded into the embeddings – so they maintain their contextual meaning. It is important, that only thereafter the resulting tuples of words and their embedding vectors are filtered. This filtering mechanism allows for assessing only the words which also occur in the eMFD and comparing them using the aforementioned bag-of-words (BoW) method. The remaining vectors are then row-wise combined (i.e. stacked) to the embedding matrix X. By default, i.e. without this filtering, all words are considered as long as they are alphabetical (i.e. only contain letters) and are not stop-words.

Reproducing the eMFD
To assess our model and compare it to the eMFD vectors, we calculate the moral vectors from our model and the eMFD tool for all 1985 validation articles used in the eMFD paper [8] – the 1010 articles for developing the eMFD were excluded for selecting a proper baseline. This is similar to how the eMFD [8] was validated against other moral dictionaries, such as the original MFD [3] and the MFD 2.0 [27]. As there could have been some noise in our model due to the linear regressions, we wanted to see how well our model reproduces the eMFD. For proper comparison, we filter out all words not occurring in the eMFD as described before and use the BoW approach for calculating the overall moral vector for the article.

Generalizability beyond the eMFD
To assess the model's generalization capabilities, the eMFD is split into training and validation subsets, each representing 50%. The

[1] https://huggingface.co/google-bert/bert-base-uncased [17]

linear regressions of our model are inferred from the training subset. We then calculate the moral vectors for all words in the testing subset and compare them with the existing vectors from the eMFD. For this, the cosine similarity was found to be a proper metric [28].

Our model should not be restricted to the words in the eMFD, but should also provide reasonable moral scores for other words. We therefore assess whether our model's moral scores of words not contained in the eMFD follow the same distribution as our model's moral scores of words in the eMFD.

Short-Text Performance
As our model generalizes to other words not contained in the eMFD, we suspect a higher performance with short texts, because more words in short texts can be used for a moral analysis than with the eMFD. We therefore compare the moral vectors of the titles, summaries and full-texts of a random 10,000-article subset of the one million articles in the RealNews dataset [29] from our model with the ones from the eMFD. As ground truths for comparison, we calculate the moral vectors from the eMFD for the whole article. So, the closer the moral vectors from the short texts are to the moral vectors of the whole article, the better the model performs for short texts. As suggested in [29] (and later also seen in section 4.2), one cannot assume the meaning or moral vectors of headlines to align with the full-text article. However, our approach of benchmarking by the correlation of headlines to full-texts is still valid, because verifying a higher correlation is a stronger indication towards correct moral measurement than a lower correlation. This is supported by the fact that the eMFD cannot capture contextual semantics and thus yields inferior correlation.

Validation via Social Effects
However, it is not sufficient to validate our model against distributions. Technically, moral scores from our model can yield completely different moral scores while maintaining the exact same distribution as the eMFD. We thus compare our model identically to how the eMFD was compared against its predecessors [8]: analyzing the moral scores of articles from news sources with different political leanings. Previous research [3, 30] has found that conservative news sources tend to emphasize binding moral foundations (loyalty, authority, and sanctity) while liberal news sources tend to emphasize the individualizing moral foundations (care and fairness). This has been largely supported by the eMFD [8].

For comparing our model, we use the same three news sources with different political leanings: *Breitbart* [31] (far-right), *The New York Times* [32] (center-left), and *The Huffington Post* [33] (far-left). We then calculate the moral scores of articles from these news sources using our model and the eMFD.

Results

Reproducing the eMFD

Similar to the comparison of the eMFD with its predecessors [8], we compared statistical properties of our model's moral scores to the eMFD scores. The scores of both the eMFD and our model follow the same distribution (see Figure 2). Both are with some exceptions normally distributed, which aligns with the findings of the eMFD paper [8].

Interestingly, all of our models predict significantly higher probability scores for all moral dimensions compared to the eMFD.

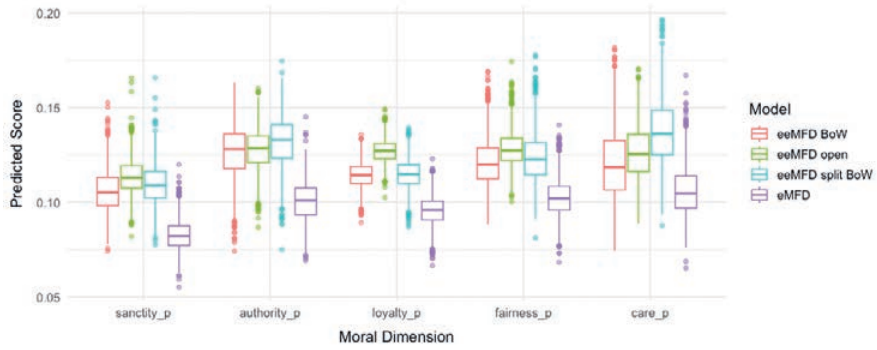


Figure 2: Distribution of Moral Scores of the Validation Articles between the eMFD and Our Model

We can also observe a visible shift in distribution within the moral dimension `care` for our model (see *eeMFD split BoW* in Figure 2). This is highly likely to be due to an unfortunate random training split, which biases the model to predict higher values. Analogously, the models *eeMFD BoW* and *eeMFD* open might not show this behavior as they were trained with the full training data, compensating for such bias. Besides the similar distribution of moral scores, we also analyzed their correlation (see Figure 3). Pearson correlation tests [26] within the same moral dimensions show that our model correlates with the eMFD scores between 0.71 and 0.82 (p-values 10^{-10}). Thus, we conclude that our model aligns with the existing moral understanding, as measured by the eMFD.

Generalizability

Our version of the model being trained only on the first half of the eMFD, also shows a correlation with the second half of the eMFD between Υ=0.59 and Υ=0.79 (*see eeMFD split BoW* in Figure 3). We conclude that our model effectively calculates moral scores of words which are not in the eMFD and can thus generalize. So, under the hood, our model finds relevant dimensions within the BERT language model that, in the main, strongly correlate[2] with moral scores in the eMFD. This is evidence for a very interesting insight about BERT's capability to recognize moral connotations.

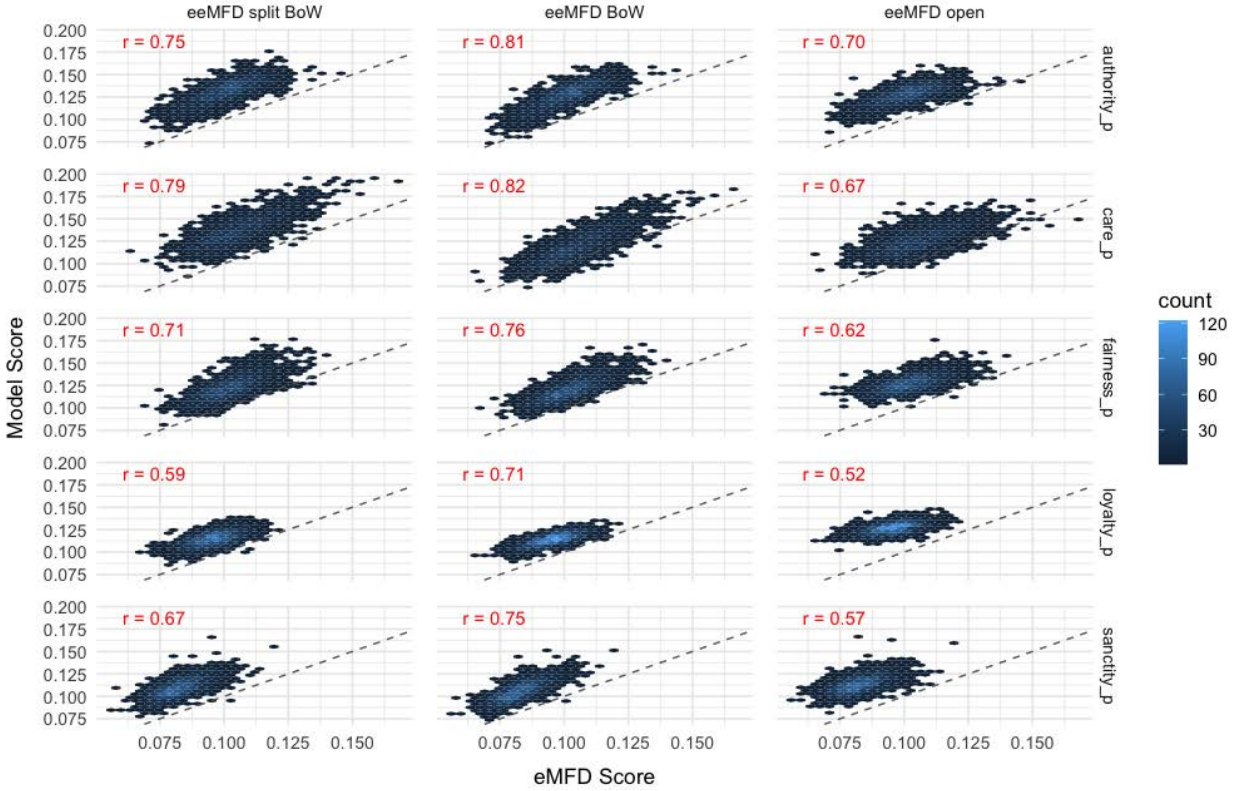


Figure 3: Rows represent the five moral dimensions. "eeMFD split BoW" shows the correlation results for testing generalizability of our model, "eeMFD BoW" shows the correlation results for reproducibility, and "eeMFD open" shows the correlation including words not within the eMFD. Each point represents the moral score of a single article in the validation dataset. The dashed diagonal represents a perfect correlation, i.e. a Pearson correlation Υ=1.

However, the correlations observed for our model trained on half the eMFD are lower compared to the model trained on the full eMFD. The difference can be explained in two ways. On the one hand, it may be that the smaller training dataset compared to a full eMFD makes generalization more difficult, simply due to its lower sample size. On the other hand, the model may overfit on the words within the eMFD. This would result in an inflated correlation optimized towards the training dataset, which does not properly reflect the model's generalization capabilities.

Our model should not be restricted to the words in the eMFD, but should also provide reasonable moral scores for other words. Fulfilling this requirement is supported by the fact that the moral scores follow the same distribution as the ones of words from the eMFD. For the correlation analysis in Figure 3, we therefore also compared a version of our model that excludes words in the eMFD (see eeMFD open Figure 3). Indeed, our model still shows a mostly strong correlation[2] with the scores of eMFD words. This indicates valid moral scores for any word in the BERT language model. Effectively, our model is a dynamic extension of the eMFD.

However, the aforementioned filtering for non-eMFD words is just for validation purposes. The full model (i.e. without word filters) yields a lower variance of the moral scores (see Figure 2) and correlates better with the eMFD than the word-filtered model for validation (see eeMFD open in Figure 3) – which is quite to be expected. Our full model yields lower absolute errors and fewer outliers than the eMFD (see Figure 4). This makes it a more reliable tool for short-text analysis.

Validation via Social Effects

The eMFD [8] was validated against previous moral dictionaries [3, 27] by analyzing the moral scores of articles from news sources with different political leanings. Previous research [3, 30] has found that conservative news sources tend to emphasize binding moral foundations (loyalty, authority, and sanctity) while liberal news sources tend to emphasize the individualizing moral foundations (care and fairness). This has been supported by the eMFD [8]. Having a look at Figure 5, the emphasis on binding moral foundations, especially authority and loyalty, are clearly visible for the far-right news source *Breitbart* in both models. However, the emphasis on

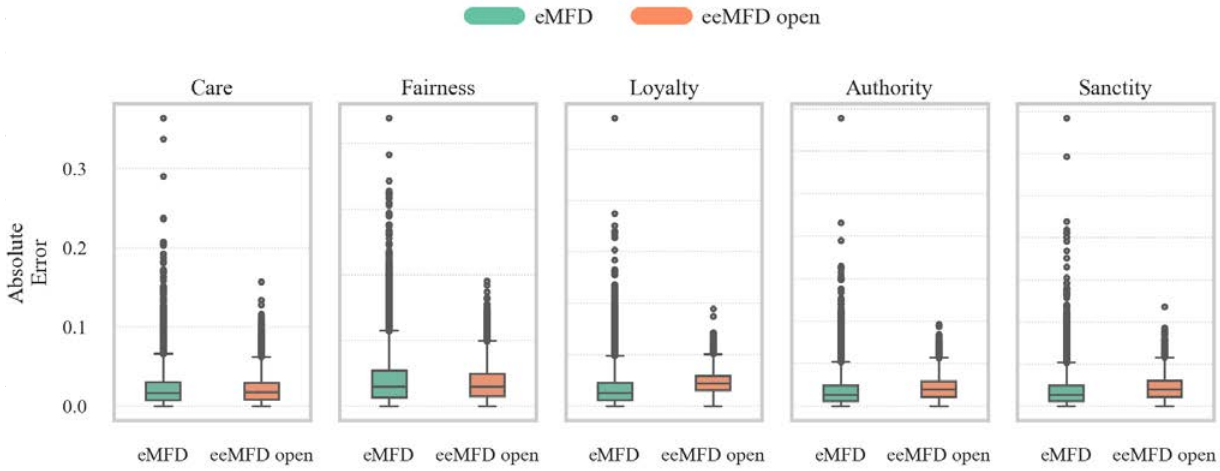


Figure 4: Absolute Error Distributions of the eMFD and Our Model

[2] Regarding a definition for which thresholds a correlation is weak, moderate or strong, we refer to the psychological definition, which is closest to our domain (see comparison in [34, Table 1]).

sanctity by *Breitbart* is not clear in either the eMFD or our model. Moreover, our model calculates higher care scores for *Breitbart* than for the other two news sources. This is in contrast to the eMFD, which shows *Breitbart* scoring similarly to *The New York Times* and *The Huffington Post.*

So overall, our model aligns with previous findings with some minor exceptions. This suggests that our model is a viable alternative to the eMFD.

Conclusion

In this research, we proposed an improved version of the eMFD which both includes contextuality to account for different meanings of the same words and shows improved performance for analyzing moral connotations on short texts.

We answered research question RQ1 regarding the context-awareness of moral measuring by combining the large-language model BERT with the eMFD. For this, we decomposed the moral vectors in the eMFD into separate vectors of the same words each in a different context (e.g. “love” as with parents or ice cream).

Research question RQ2 regarding the extension of the eMFD was answered with the same method, essentially focusing on the fact that BERT models many more words than the eMFD. By decomposing moral vectors onto the embeddings in the BERT model, we could calculate moral vectors for any word within BERT – including the ones not contained in the eMFD. Especially for calculating moral values of short texts, our model shows superior performance over the eMFD.

Our research is expected to impact multiple facets of computational social science – especially in the fields of detecting neutrality in text or fake-news detection in social media domains.

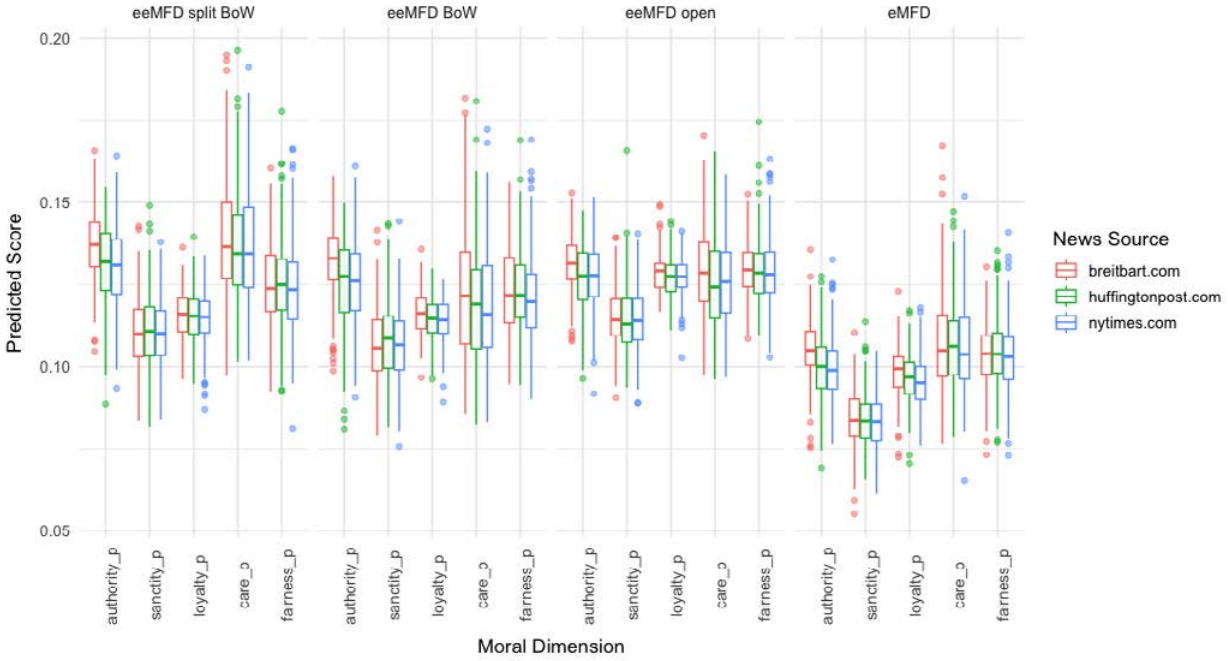


Figure 5: Moral Scores from the Validation Dataset Comparing Our Model to the eMFD

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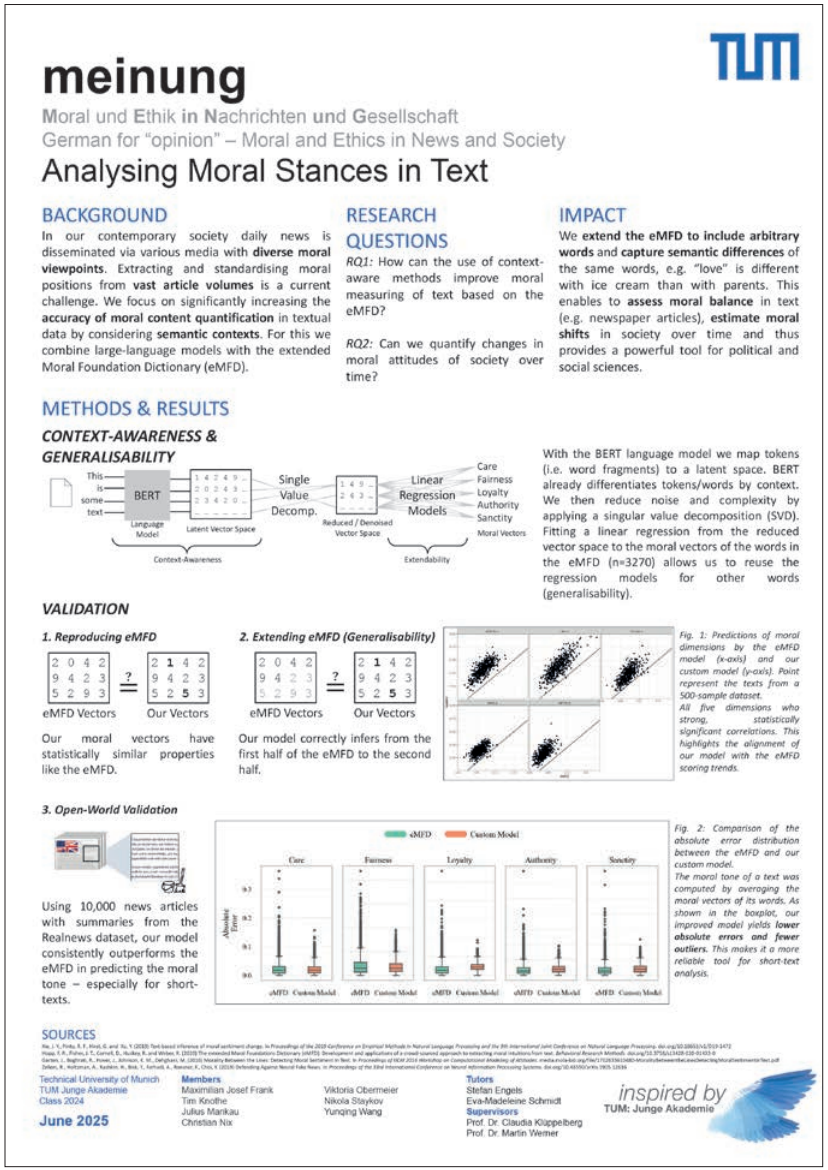
Process description



Our interdisciplinary project began in late 2023 with the goal of analyzing moral language in newspaper articles. After an initial literature review, we structured our research around the Extended Moral Foundations Dictionary (eMFD), a tool that identifies moral content in texts. However, since the eMFD lacks context sensitivity – e.g., the word "love" varies by usage – we enhanced it with natural language processing (NLP) techniques to better capture contextual meaning.

We focused on various newspaper articles to explore two main questions: Can the eMFD be used to quantify shifts in moral attitudes during critical events? And how can its context sensitivity be improved using modern NLP methods?

Our analysis involved two parallel approaches: one purely dictionary-based, and one combining the eMFD with NLP techniques. This dual strategy enabled us to compare traditional and context-aware methods of moral analysis. We collected thousands of articles from US and UK news sources using a custom algorithm.

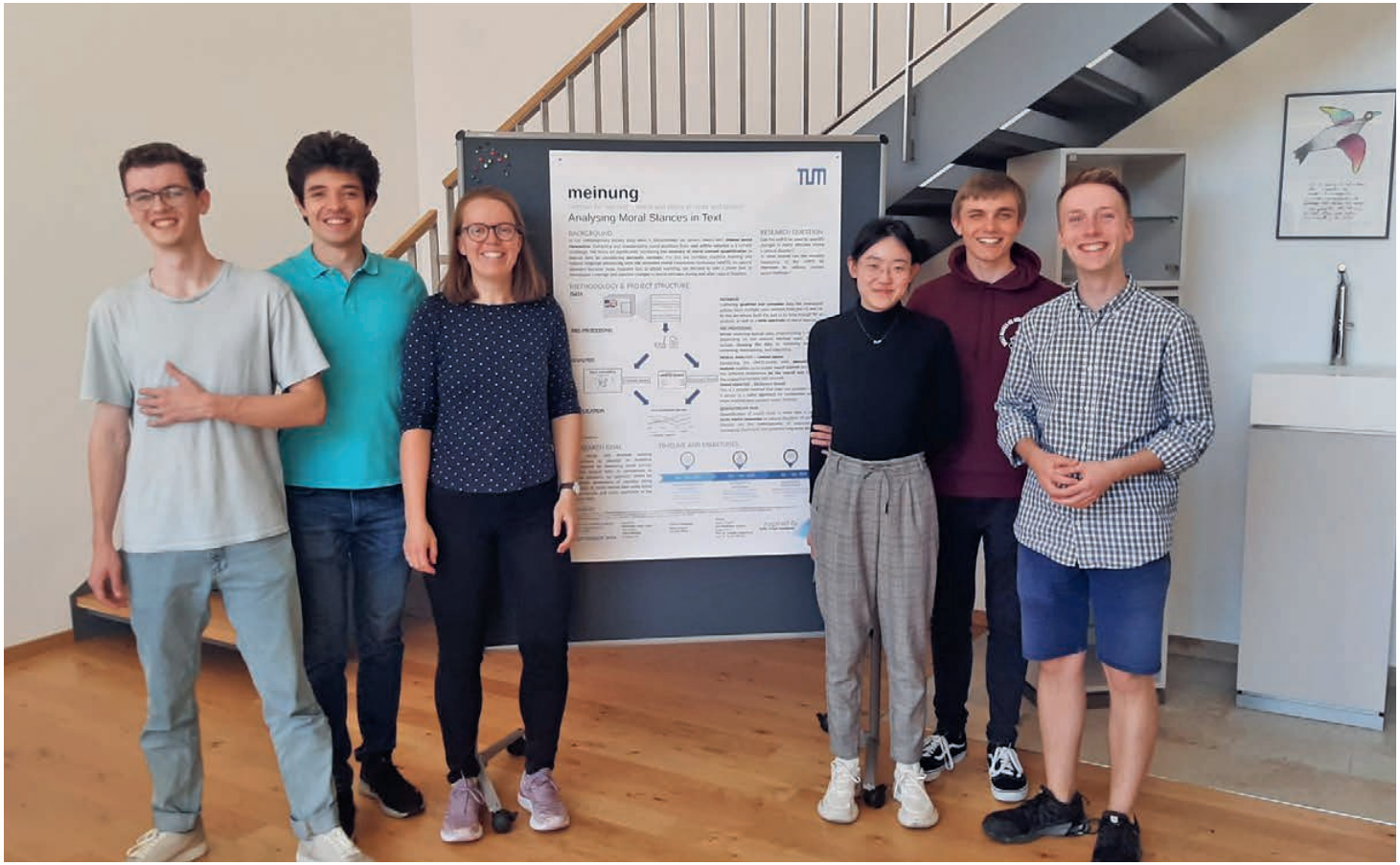
Throughout the project, we refined our methods during coding weekends, presented our results in a poster at a scientific conference, and incorporated feedback from both peers and experts. Our final phase included writing a research paper and preparing for the symposium, with a focus on tracing moral shifts over time and improving the eMFD's ability to capture nuanced moral expressions.

Self-Reflection

First and foremost, we would like to thank our supervisors, Prof. Claudia Klüppelberg and Prof. Martin Werner. Their consistent support and constructive feedback were instrumental in helping us stay focused and achieve results. We are also deeply grateful to our tutors, Stefan Engels and Eva-Madeleine Schmidt, who provided outstanding guidance throughout the project. Their availability and willingness to support us at any time ensured that we always had someone to turn to for advice.

Reflecting on the past 18 months, there may be some challenges leading to valuable insights and important lessons. These lessons can be crucial not only for personal development but also serve as a helpful guide for future teams at TUMJA.

Backup Plan: At the beginning, we needed to determine how to objectively measure morality, which seems to be impossible at first. After we realized the complexity of our task, we started to split



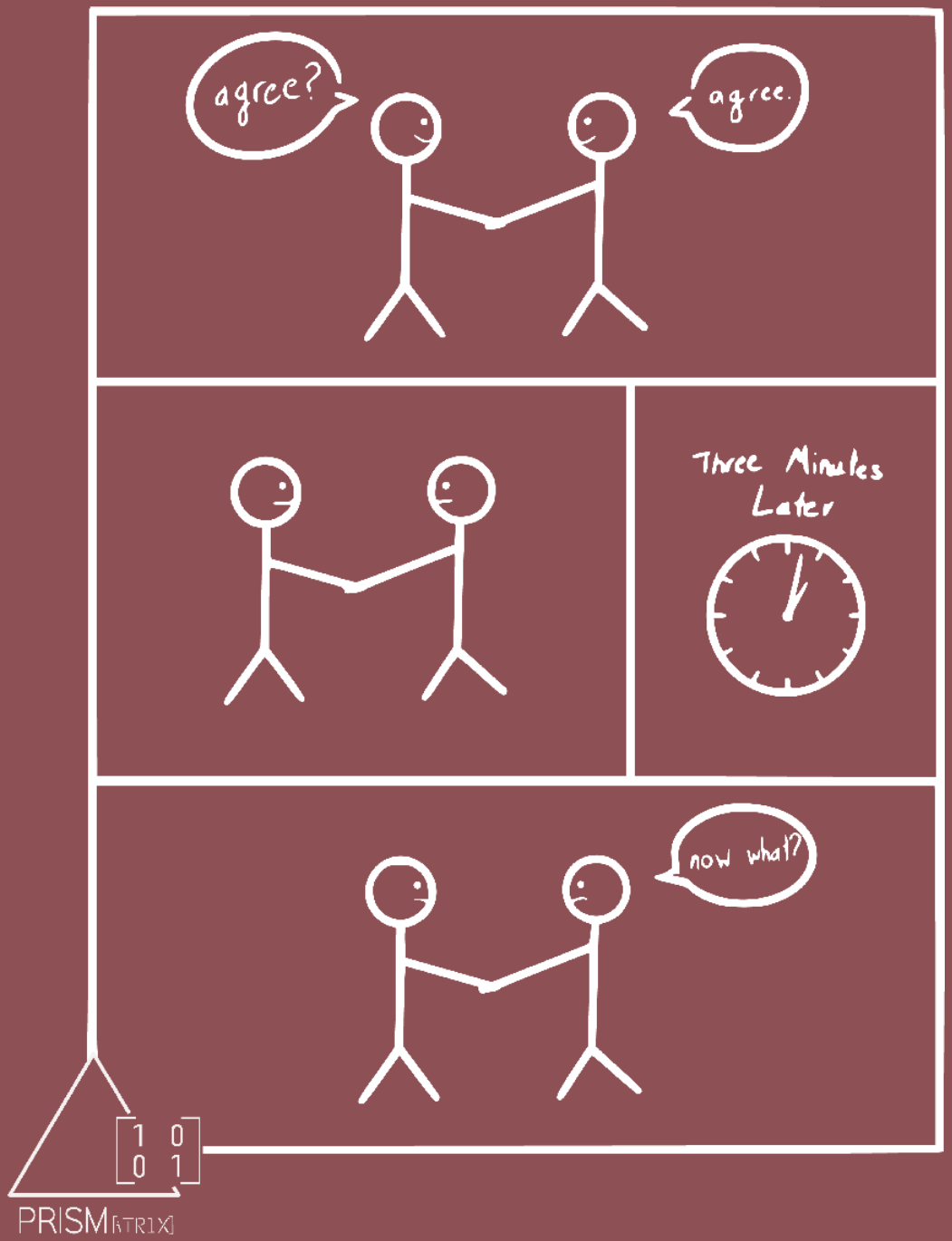
the project into two parallel sub-targets: first, continuing our initial goal to improve current methods of objective moral measuring (i.e., differentiating between words in different contexts by natural language processing), and second, measuring morality in a concrete application context. If we would have failed in our first goal, then we could still complete the second goal by using currently existing methodology (i.e., the pure dictionary approach). So, the extended Moral Foundations Dictionary (eMFD) not only became the foundation of our project but also served as our safety net at the same time. Even though we made progress in both goals, this strategy proved to be right due to unsatisfactory results. Additionally, narrowing down the topic to a concrete application gave us a clear vision of how our results might take shape. This eased the validation of the results regarding coherence and soundness.

Time-Management, Productivity, and Diversity: One of our biggest challenges was time management during peak periods of studying and working, especially exam periods. However, with our seven team members, we managed to distribute the workload quite well according to everyone's schedule and availability. Our team members came from diverse academic backgrounds, had varying strengths, and were often working in different countries.

This diversity required us to plan ahead while remaining flexible. We frequently adjusted the timing of our meetings, divided tasks, and allowed sub-teams to set their own schedules while adhering to overall deadlines. This structure allowed us to leverage each member's expertise and ensured that everyone could contribute meaningfully. In particular, the seminar weekends and our coding weekends, which combined project work with team-building, helped us stay focused and keep each other up to date. Especially after the initial project-forming phase, moving from weekly meetings to monthly coding weekends greatly increased productivity.

A valuable tip for future projects: Start working on your project early. This helped us immensely, especially when our initial ideas didn't stick.

Overall, the TUMJA research project was a great preparation for future scientific projects in interdisciplinary teams and for further specialization in our future careers. We value the connections we made – both professional and personal – and look forward to staying in touch.


agree?
agree.
Three Minutes Later
now what?
PRISM[MATRIX]

Research Report **PRISMatrix**

The mathematical performance of students in Germany has noticeably decreased in the past few years. Given that mathematics is important in our daily lives, we, team PRISMatrix, set out to get a deeper understanding of what causes this issue. While there exists a lot of quantitative research done on this matter, we opted to look into the understanding of the issue of individuals in different stakeholder groups. We interviewed students, teachers in training, public figures, and scientists to focus on their personal experiences and assess their representation in the data we have. We hoped to find disagreements or gaps in their views, which point to a root cause of the declining mathematical performance.

Team	Abhirami Sreeprakash Bushra Demyati Elke Haldmaier Konstanze Maria Dietlmaier Lucia Arens Marius Prock Praissya Nathania
Tutors	Andrea Schittenhelm Altan Birler
Supervisor	Prof. Dr. Jörg Niewöhner

Preface by the Supervisor

Prof. Dr. Jörg Niewöhner

Dear Readers,

Were you one of those people who really did not enjoy maths at school? Did you feel that numbers simply weren't for you, and you lost touch before you really knew what was happening? Or, perhaps more likely if you are now a member of the TUM family, you liked maths but lessons seemed so out of touch with real-world problems, just going through calculation after calculation?

Well, you are in good company because, apparently, that is how many kids feel about maths at school these days. And in particular, girls. Grades in Germany are in decline accordingly. Combine that with more general discourses about gendered roles, preferences, and abilities, and you have part of your answer to why STEM subjects at university struggle to attract more women.

The PRISMatrix group of scholarship holders at TUMJA started to wonder about this, too. And they set out on an empirical path to better understand why this might be happening and, more importantly, what kinds of solutions to this problem are on offer. They embarked on an empirical journey to meet the experts: in teaching, in the science of teaching, and in politics. They asked, listened, interpreted, mapped, analyzed, and argued.

The results … but I do not want to spoil it for you. Just to say that they are somewhat surprising to the group and perhaps also to you. PRISMatrix did not at all end up where they thought they would. I guess that is what research is all about, and that is what working in a collective is all about.

I sincerely thank the team for having the courage to explore territory unknown to them conceptually, methodologically, and disciplinary. They stuck with it, did not lose sight of their goals despite busy schedules and the madness that is the world these days. Well done to all of you!

And to you, the readers: Enjoy the results and maybe have a quiet moment to think about how that can be true and what this means for how we organize our society, our education, and our future.

Thank you and all the best, Jörg Niewöhner. ■

Supervisor Insights

I have been educated as a scientist in an interdisciplinary environmental science department that, since the 1960s, insisted that environmental issues and problems do not fall neatly into disciplinary categories. Ever since, I have been interested in how science organizes itself, its thought styles, its practices, and its everyday life. Now, I call myself an anthropologist of science & technology, and TUM's everyday life is my object of research. What do we need to change to ensure that everything we do furthers a public good, social-ecological integrity, academic freedom, and just ways of living together?

Taking questions of justice, of fairness, of sustainability, and of shared futures into a technical university is an important challenge. If we wait for technology to reach markets to assess their impact, it is too late. We need engineers and scientists to consider the broader implications of every choice they make during their exciting journey into new territories. This is a matter of early education, and it is a collective effort across disciplinary boundaries. That is why the work that the Junge Akademie does is so important. It exposes bright students at an early stage of their education to wildly different ways of working, worldviews, and scientific practices. Who knows what will come of this. Most likely lots of different things. This is about praxis, not poiesis – it is about doing something together with others.

Jörg Niewöhner, Chair for the Anthropology of Science & Technology (SOT/STS)

The Journey of PRISMatrix

Understanding Math Education: Why Agreement Isn't Enough to Solve the Problem

The sun is shining through the window on a group of 4th graders huddled around a table in the center of the classroom. Four heads lean over a sheet of encrypted text. One student is holding a paper coding disc, turning it carefully in his hands. While the atmosphere is one of concentration, soft yet excited chatter fills the room. There are other groups scattered on sofas and on the floor, discussing their next steps. My teammate and I walk around and listen in on their conversations. Soon, the energy shifts as eyes start darting around the room, searching for help. The excitement about the task fades and a few shoulders sag. Some students grow restless and start fidgeting. In a small group of four, one boy slumps onto the couch. I head over. "How is it going? How far are you?" After a mere three minutes of unsuccessful trying, his initial motivation is worn out. He comments on the difficulty of the task and concludes that he won't be able to decipher the text anyway, no matter how much time he puts into it. We rejoin his group, and I guide them through the next step by offering a small hint. They begin testing their decoding disk. Once their confidence has rebuilt, I step back, allowing them space to work on their own again. Why do students give up so easily and how can they be motivated? This is a question that is typical within the education field. It's on teachers to keep their students motivated and teach new concepts, while still managing to keep good order.

But is it the only challenge? The latest PISA study in 2022 showed a decline in the math performance of ninth graders in Germany. These results intensified the debate about the reasons for our pupils' increasing difficulties in mathematics. In order to find out more about the current debate around mathematics education, we created our research project, "PRISMatrix." Supported by TUMJA, our team explored and compared different perspectives on factors that influence the math performance of German students. We conducted 28 interviews with students, teachers in training, scientists, and politicians, and we performed a qualitative analysis to find agreements and disagreements between the groups. While politicians and scientists adopted a systemic perspective and addressed overarching challenges, the future teachers and students focused on conditions within their profession or classroom experience. Interestingly, all stakeholder groups shared a common understanding of problems and factors within the debate: They had a clear and similar vision of ideal math lessons and suggested new teaching concepts, as well as more tasks with real-life relevance. For our 90-minute workshop at the Schülerforschungszentrum Berchtesgaden in January 2025, we therefore planned an interactive detective story. It guided the kids through creative, open, and challenging math tasks.

Back in the classroom, the students continue with the next task. The girl sitting next to me barely answers my questions. Her teacher had informed us that she did not talk much in general. She sits listlessly and watches her teammates solve the riddle. Her language barrier further complicates active participation in the group's discussions. In our interviews, students often preferred group work since it provides mutual support and motivation. Still, in this case, the girl could neither participate nor benefit from those advantages. While I am still trying to help her to engage in the group, another student yells from the other side of the room "We're ready. We know the solution." The group was way faster than we had expected them to be. We had prepared additional tasks, but they still finished before everybody else and soon got bored. A situation that the interviewed teachers in training knew well since they deal with a high heterogeneity in students' competencies every day. Our interviewees suggested differentiation and individual support as solutions. However, large classes, lack of time, and missing teaching personnel make this challenging.

Our interviews showed that all stakeholders understand the problems and possible solutions. So why do the problems persist? Is it a question of priority? As one of our interviewed politicians said: We talk instead of acting. Employing more teachers, reducing the workload or developing new class concepts seem feasible. If we truly wanted to, couldn't we increase the public funding for education, adapt the teaching study program or offer more individualized sup-

port to the students? As we all know, the children of today are the future of tomorrow. Shouldn't we give our best for their future now? The question of priority shows similarities to the climate change debate: Science is clear on consequences. However, according to the EIB climate survey[1] from 2024, 92% of people living in Germany think changes are needed, but only 40% feel it is a priority in the next year.

Maybe real change is too complicated. Influencing factors are strongly intertwined, which complicates the prediction of consequences. Our interviewees described vicious cycles. Students and teachers recognized bad grades as core to negative self-enforcing patterns, like losing motivation and stopping work on math skills. Here, teachers in training also saw missing teaching personnel or the teachers' lack of time and resources as barriers to providing individual support for those students. Politicians further mentioned that staff shortage leads to time pressure and increased workload, making the teaching profession unattractive. Additionally, the high heterogeneity in competencies among students requires differentiated tasks and teaching, which demands more preparation and exhausts teachers notably. As individual support is lacking, the gaps widen, worsening the situation for teachers and students alike and ending in a vicious cycle. Changing one element in this cycle could influence other factors in an unforeseen way. So, do we simply not know where to begin and which adjustment to make first? Are we too stuck and too confident in the current system to pursue significant systemic changes? In the current education field, a creative and progressive lesson design depends on the commitment of individual teachers. While their initiative is certainly commendable, having a system that inherently supports the math education that all stakeholders wished for would still be beneficial.

It is almost noon now on this sunny day in Berchtesgaden. The groups have just completed their last task, so we wrapped up our detective story: They solved the case and, as a reward, became

honorary members of the secret Mathematics Society. They seemed to have enjoyed the task that involved drawing and symmetry the most. A few cheers and other expressions of joy echo through the room. At least on that day, we succeeded in exciting them about math by giving them creative and active group exercises. It likely won't change much in how many will eventually lose interest and enjoyment in mathematics, but it was a start. Implementing some of the interviewees' ideas on solutions worked. It showed that change is possible, and the necessary knowledge already exists. Creatively taught classes full of fun and excitement about math can become the rule, rather than the exception. Ideally, we could have an education system that ensures the best for our children – the future of tomorrow. ■

1 European Investment Bank. (2024). The EIB climate survey: Attitudes towards climate change adaptation : 7th edition 2024. Publications Office. https://data.europa.eu/doi/10.2867/4661519

Research Report – PRISMatrix

Controversy or Consensus? – A Qualitative Analysis of the Debate on Math Education in Germany

Table of contents:

Abstract

The 2022 PISA study showed a significant decline in the mathematical performance of German pupils. We aimed to gather the opinions of different stakeholders on the causes of this decline and possible solutions. We compared the broad categories of these factors between the stakeholder groups.

We conducted 28 semi-structured interviews with students, teachers in training, scientists, and public figures. We used a grounded-theory-based methodology. All factors were categorized and mapped to show overlaps and connections.

The stakeholders identified problems such as outdated teaching methods, lack of practical applications, and pressure caused by overloaded curricula and understaffing. Politicians, teachers in training, and scientists agree on a pedagogically versed use of digital tools. The former two criticize the education of future teachers and the exclusion of teachers and scientists in finding solutions.

Our results indicate a shared understanding of the factors and potential solutions for the declining mathematics performance of students. Interdependencies between the factors may cause the issue to remain unsolved despite general agreement.

1 Background

The Program for International Student Assessment (PISA), conducted by the Organization for Economic Co-operation and Development (OECD), assesses the skills and knowledge of 15-year-old students in mathematics, reading, and science. Comprehensive and sufficient knowledge in mathematics, computer science, natural sciences, and technology is crucial for future Science, Technology, Engineering, and Mathematics (STEM) professionals (acatech & Joachim Herz Stiftung, 2024). However, the results from PISA 2022 revealed a significant decline in the mathematics performance of ninth graders in Germany compared to previous PISA cycles (OECD, 2023). Although Germany scored slightly above the OECD average in mathematics and reading, only 70% of German students achieved at least level two proficiency in mathematics, at which students can use mathematics in simple real-life situations.

In comparison, over 85% of students in Japan, Chinese Taipei, and Estonia reached level two or higher. Moreover, performance trends have been steadily declining since 2012, with a significant drop in mathematics in 2022 (OECD, 2023).

To find and implement customized solutions, it is important to identify the factors responsible for the students' decline in mathematical performance. Several studies were conducted globally to find possible factors influencing mathematical performance (Aldon et al., 2021; Forsa, 2020; Sturzbecher et al., 2021; Ramirez et al., 2016; Schillinger et al., 2018; Svraka et al., 2024; Algani & Eshan, 2019). Wang and colleagues (2023) suggest that the factors emerge across various levels, ranging from individual characteristics to broader societal influences (Wang et al., 2023).

Education systems are complex and involve many stakeholders. Varying interests, societal values, and economic demands make different educational priorities inevitable. Policymakers commonly focus on performance metrics and international competitiveness when considering the available budget. For instance, as a response to the results of PISA 2022, Bavaria's education minister, Anna Stolz, introduced additional German and math lessons in primary schools. However, this resulted in cuts of art, music, craft, or English lessons (Günther, 2024). On the other hand, teachers often focus on classroom dynamics, student well-being, and individual needs. These differing priorities may result in fragmented and ineffective solutions, as stakeholders' needs are overlooked or fail to align.

According to the literature, the factors responsible for the declining mathematical performance and interest among the students over the years can be due to the COVID-19 pandemic (Aldon et al., 2021; Forsa, 2020; Sturzbecher et al., 2021), mathematical anxiety (Ramirez et al., 2016; Schillinger et al., 2018; Svraka et al., 2024), gender differences, socio-economic factors of the family, teaching methods, school and curriculum differences, and many more (Algani & Eshan, 2019; Wang et al., 2023).

The COVID-19 pandemic impacted the German education system due to school closures and distance learning. The quality of distance learning was inadequate to support lower-performing students and students whose parents have no academic background (Aldon et al., 2021). Students and parents reported a decreased effective learning time (Sturzbecher et al., 2021).

Math anxiety is a feeling of stress or worry when dealing with math, leading to negative thoughts, avoidance of the subject, and lower confidence and motivation. Higher anxiety is linked to poorer math performance (Schillinger et al., 2018). Often, students feel anxious because they believe they already struggle with math, creating a cycle where anxiety and low performance reinforce each other. Research shows that students with moderate to less math anxiety exhibit better performance than those with high anxiety (Svraka et al., 2024). Math anxiety makes it harder to focus and use problem-solving strategies. Students who tend to use simpler strategies are less impacted by anxiety but usually achieve lower math scores overall (Ramirez et al., 2016).

Algani and Eshan (2019) categorized the factors for low math achievement as follows: student-related (e.g., limited mental abilities, health/psychological challenges, and poor social adjustment), teacher-related (low scientific competence, inadequate teaching methods/experience), curriculum-related (unclear objectives, poorly presented material, weak assessment tools), school-related (outdated infrastructure, insufficient labs/ classrooms), and family-related issues (financial instability, low cultural/scientific support). Students' deficits hinder knowledge acquisition, while ineffective teaching and disorganized curricula foster disengagement. Poor school environments limit learning opportunities, and family hardships shift focus from education to survival needs, collectively undermining academic performance (Algani & Eshan, 2019).

To investigate major factors driving PISA math achievement for all OECD countries, Wang et al. systematically reviewed 154 research papers. Unlike the previous study conducted in Israel, this review adopted a broader perspective by categorizing the influencing factors into five hierarchical levels: individual level, household context, school community, education systems and macro society (Wang et al., 2023).

Previous studies have primarily focused on generalizability or quantitative data, often overlooking a deeper exploration of the underlying reasons behind educational trends. Given the complexity in the education system, including the diverse scopes of work and limitations faced by each stakeholder, it is crucial to see both agreements and disagreements among these groups. Thus, this research adopts an exploratory approach using semi-structured interviews to gain personal insights from each stakeholder. By mapping the factors' interdependencies and discovering connections between stakeholders, we seek to answer the following research question: "What are the agreements, disagreements, and gaps between the reasons for the decline in mathematical performance among ninth graders identified by scientists, public figures, teachers in training, and students?"

2 Methodology

2.1 Participants and Interview Guide

To gain insight into the perspectives of the different stakeholders, we conducted 28 interviews with 13 students, seven teachers in training, five scientists, and three public figures. The interview process began in October 2024 and lasted until January 2025. Participants among students and teachers in training were found through advertising at events in Munich (Münchner Wissenschaftstage, 28-30 June 2024, TUM student club fair, 23 October 2024), on our website, and through personal contacts. Scientists and public figures were contacted directly. All interviewees gave their written consent to participate in the study and to process their data.

2.1.1 Students

Interviews with 13 students with an average duration of 19.84 ± 6.32 minutes (range: 9 to 30 minutes) were conducted. The students had an average age of 15.1 ± 2.69 years and attended schools in Bavaria (N=6), Baden-Württemberg (N=6), and Niedersachsen (N=1). While more than half of the students attended Gymnasium (N=7), other school forms were represented, including primary school (N=1), Realschule (N=2), Fachliche Oberschule (N=1), berufliches Gymnasium (N=1), and Waldorfschule (N=1). Since school lessons are the students' main exposure to mathematics, questions focused on their former and current experiences in math class. Students were asked to recount their last math lesson. They described what they like or dislike and what their ideal math lesson would look like. To change perspective, every student was asked to imagine being a math teacher and planning their own lesson, with complete creative freedom and no restrictions regarding time, topic, or material. Further topics included the applications of mathematics in other fields and jobs. We opted to ask the students to self-assess their performance and interest in math. We did not ask for specific grades, allowing the students to talk about their actual experience in class without feeling judged by their performance. 53.8% of students said they enjoyed math class (n=7), and 61.5% declared math to be easy for them (n=8).

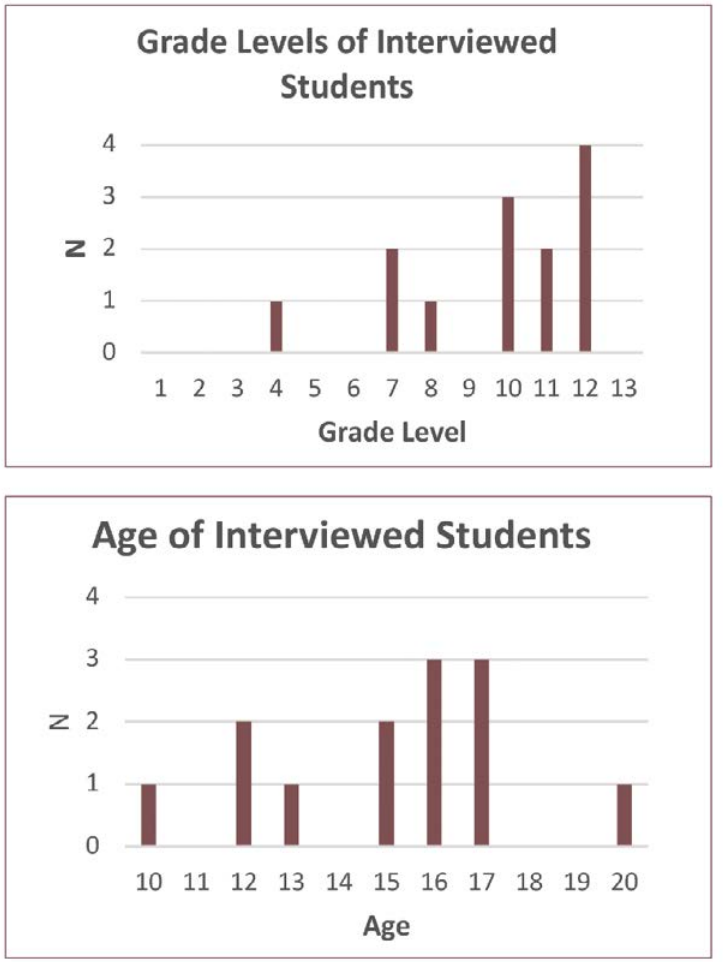


Figure 1. Grade levels and ages of the students interviewed for our research.

2.1.2 Teachers in Training

Due to legal restrictions, interviews with active teachers were not possible, so we instead interviewed teachers in training. Seven interviews with an average duration of 49.28 ± 21.24 minutes (range: 25 to 93 minutes) were conducted. Five studied for a teaching position at the Gymnasium level and two for primary school. Overall, five studied in Bavaria and two in Baden-Württemberg. All were in advanced semesters and had already completed mandatory internships in schools for at least three months. The internships included unassisted teaching and observing experienced colleagues. Four interviewees had additional experience from tutoring and voluntary help in schools. The interview questions focused on their perception of the PISA study based on their personal opinions and discussions in their studies. Furthermore, possible factors influencing mathematical interest and performance, the structure of math lessons, and teacher-student interaction were discussed. Finally, they were asked about the connection between creativity and math and its implementation during lessons.

Questions about lesson structure, introduction of new mathematical topics, and teacher-student relationship were asked in student and teacher interviews to compare both perspectives.

Variable		N
Current Study Semester		
	3	1
	6	1
	7	1
	9	3
	14	1
2nd Teaching Subject		
	Physics	3
	Philosophy	1
	Computer Science	1
	French	1
	Religion	1

Table 1. Study semester and second teaching subject of interviewed teachers in training

2.1.3 Scientists and Public Figures

Interviews with four scientists and four public figures were conducted. The interviews with scientists had an average duration of 67 ± 29.19 minutes, and those with public figures had an average duration of 40 ± 8.16 minutes. Interviewed scientists specialized in educational research, focusing on school education and learning psychology. All public figures were actively engaged in educational policy and advocacy in Bavaria, with two individuals having past teaching experience. The representatives came from associations concerned with school policy and educational reforms, while the politicians were members of Bavarian education committees. The interview questions of both groups focused on the perception of the PISA results, the factors responsible for the decline, as well as the possible solutions. Additionally, educational policy frameworks and the role of creativity in mathematics education were discussed.

2.2 Data collection

The interviews were conducted in person or virtually via the videoconferencing application Zoom (Zoom Video Communications). The language varied between German and English, depending on the interviewee's preference. Direct quotes in the following chapters were translated from German. The interviews were semi-structured, i.e., the interviewers had a pre-determined set of open questions while staying flexible to explore responses and bring up new ideas. This allowed the interviewees to express their opinions and give reasons for their answers more freely.

2.3 Data analysis

To answer our research question, we applied a grounded-theory-based methodology. We did not start with a preconceived notion of what factors influenced mathematical performance but allowed theories and hypotheses to emerge from the raw contextual data. The main idea of the coding process is the iterative "constant comparative method." Data collection and analysis occurred simultaneously, each enhancing the other. This cyclic interaction between data collection and analysis ensured that the emerging theory is deeply rooted in the data (Strübing, 2021). Thus, the interview guides were also adjusted iteratively to consider the experience from former interviews and the results of the interview coding.

2.3.1 Interview coding

All interviews were recorded and auto-transcribed verbatim using the software f4 (f4transkript, Dr. Dresing & Pehl GmbH). Each inter-

view was coded by one group member. We had five coders in total. We applied an inductive approach during the initial open coding phase. During the process, each coder developed their own categories that fit best for the given dataset. We only fixed three overarching categories: Factors, Reasons and Problems; Solutions and Changes; PISA-related statements. The smallest entity to which a code could be assigned was one sentence. The relationship between the different categories was explored during the axial coding phase. Related codes were clustered into larger categories.

2.3.2 Mapping

To integrate the different categories into an overarching concept, we initially used the method of controversy mapping from science and technology studies, allowing an analysis of complex debates where science and society intersect. The goal is not to determine "right and wrong" but to understand how the debate functions by mapping it objectively. Claims, counterclaims, and opinions were collected from the interview codes. Due to the stakeholders' high agreement, we changed to analyzing the relationship of actors and factors based on the situational mapping of Clarke (2005). To improve visualization, each stakeholder group was mapped separately using the digital collaboration platform Miro (RealtimeBoard Inc. dba Miro). Factors and their overarching categories were visualized, with arrows or colors resembling connections. To compare opinions and identify gaps or contradictions in factors, we compared those categories across the mapping of different stakeholders.

3 Outcomes and Discussion

3.1 Results of Student Interviews

The students interviewed on the decline in mathematical performance emphasized the influence of the lack of applications and purpose of exercises; the student-teacher relationship; the teacher's behavior and attitude towards teaching and towards the students; the pressure to perform well; time constraints; and incompetent teachers..

The students stressed how lacking real-world context for the materials taught influences their motivation, especially in more advanced, and often more abstract, levels. The students mentioned how they would incorporate creative and practical introductions, involving physical objects, if possible, if they were the ones teaching mathematics (S2, S8, S9). They were able to recall classes with collaborative and imaginative tasks, such as songs, paper-folding competitions, and group work (S3, S7). A very interesting project incorporated informatics to implement the mathematical algorithms learned (S4). Much to the student's dismay, this initiative was stopped due to a lack of time.

Most students favored group work due to the mutual support, motivation, and alternative explanations by classmates it provides (S3, S4, S5, S7, S8, S10). Others mentioned the motivation and feeling of accomplishment doing tasks on their own provides (S3, S8). Moreover, the students were able to give a wide range of applications of mathematics (S3, S4), as shown in Table 2, while also not being able to relate the teaching materials with these applications (S2). Most mentioned how they never discuss the applications in class (S1, S4, S7, S8, S11, S13).

Application	Number of times mentioned
Everyday life (shopping, finances, taxes, etc.)	8
Construction and architecture	4
Further education	3
Economics	3
Computer science	2
Natural sciences (medicine, physics, biology, etc.)	2
Understanding natural phenomena (e.g., ebb and flow)	1
Meteorology	1
Logical thinking	1
Engineering	1

Table 2. Number of mentioned applications of mathematics by students.

Moreover, the student-teacher relationship often determined if the students looked forward to class and had fun with the subject (S6, S7, S9, S10, S12, S13). The students' favorite subjects depended heavily on the teacher (S8, S9). Showing interest in the students' learning process, regularly collecting feedback, and asking about the students' well-being are desirable teacher traits (S6, S8). Students mentioned how devoting time to individual support and feedback sessions is limited due to the teachers' workload and overloaded curricula.

It is often the case that a cycle forms for students, either positive or negative. Depending on the grades, the motivation of the student changes, which in turn affects their participation and willingness to learn and put in effort in learning. This, consequently, affects their grades, which starts the whole cycle again (S3, S8, S9, S10, S13). Therefore, it is possible to influence one of these factors to affect the other ones, and lead to reinforcing a positive cycle of cause and effect.

To combat the factors previously mentioned, students proposed that teaching methods should involve more relevance and significance to real-life situations (S2, S8, S9, S10). This requires more creative teaching strategies such as: well-chosen case examples (S5, S6, S7, S9, S13); repetition and linking to past topics (S6, S9); and visualizations with the help of objects and sketches in exercise (S6, S7, S9, S10). Having smaller class sizes would also increase student-teacher interactions (S5, S6, S8).

3.2 Results of Interviews with Teachers in Training

The teachers in training interviewed viewed the main factors causing the decline in mathematical performance to be the lack of practical guidance in their training; time constraints due to tight timetables and shortage of teachers; and teacher-centered instructions with little student interaction and outdated teaching methods. Some see the parents and their influence on students' attitudes to the subject as a problem. The teachers in training also mentioned how ill-prepared the school system was to online teaching during the COVID-19 pandemic, due to poor organization of online classes and missing technical equipment, leading to a decrease in the students' interest and participation (T4–T6).

Teachers in training said that their studies were mainly theoretical with insufficient practical guidance and preparation for dealing with real-life problems in classrooms. They wished for more practical insights through longer internships or dual courses of study (T1, T3, T4, T5, T7), since a dual course of study would lighten the load of schools with teacher shortages (T3). In Thuringia, a pilot program of dual studies for teachers started in the winter semester 24/25 at the university of Erfurt. In this program, the teachers in training were a part of partner schools' teaching staff throughout their studies (Ministerium für Bildung, Wissenschaft und Kultur, n.d.). The teachers in training wished that this program would be made more widely accessible (T3).

All interviewees saw digital technologies as positive. However, it was stressed that they must be used in the right way to be effective (T1, T3, T5). Even though implementing digital technologies is discussed theoretically at the university, no practical experience in real-life settings is gained (T5) or the school lacks the necessary equipment (T3).

Moreover, the teachers in training mentioned how the motivation and interest of students in mathematics depend heavily on the teaching style (T1, T3). The age distribution of teachers was seen as a problem in this context, as older teachers are often unwilling to adapt their methods (T1). They also stressed how difficult it is to implement creative methods that would make the lessons more fun and motivating, due to lack of time and resources (T1, T3, T5).

In addition, the teachers in training agreed that the gaps in mathematical knowledge and interest require varied teaching approaches; individual support (T2, T3); free learning platforms and targeted tutoring (T5); and allowing students to make mistakes and learn from them. They see creative methods and a positive classroom environment as key to motivating students; they emphasize the importance of stimulating the students' interest and curiosity from primary school levels.

Moreover, giving teachers more time and resources to help students individually was seen as the most pressing issue (T3). The teachers in training were willing to implement new approaches and plan motivating and creative lessons if given the opportunity. They also suggested having a clear differentiation between the students' levels in mathematics in order to have more compatible teaching methods and materials (T1–T7). Establishing networking and platforms for fellow teachers to share materials and experiences would be helpful as well (T5).

Lastly, the recent results of the PISA study are very present in the studies of prospective teachers. This began with the "PISA Schock," the strong reactions of the German public to the publication of the first PISA results in 2001 when German students performed below average and significant differences between German states were shown (Tillmann, 2015). The current PISA results were frequently discussed in lectures concerning psychology and didactics (T1–T7). One often discussed development was

the introduction of a competency-oriented curriculum after the first PISA results (T3, T5). This new curriculum would no longer be exercise-oriented but it would rather focus on applications and problem solving (PISA 2022, 2023). It was stressed that the PISA study measures certain mathematical competencies, but neglects social and emotional competencies, which should be taught in school and are closely linked to learning success (T2). Teachers in training emphasized the need for support from politicians and collaboration with scientists to develop effective teaching methods in response to PISA (T1–T3).

3.3 Results of Public Figures Interviews

Regarding mathematics education, our interviewees saw problems related to the teaching profession (P1, P3, P4), social aspects (P2–P4), classroom realities, political decisions, the educational approach and lesson design (P1–P4).

They are aware that the teaching profession is unattractive due to time pressure and high workload, rooted in a shortage of teachers (P1, P4). Pressure to complete the curriculum limits comprehensive teaching (P3). Proposed solutions include hiring additional staff, offering professional development, and increasing practical components in teacher education (P4).

In classrooms, the heterogeneity in student competencies necessitates differentiation (P3). The associated time-consuming preparation and exhaustion during teaching push teachers to their limits (P3), leading to a vicious cycle: The time pressure hinders differentiation and individual support (P1, P4), thus widening the skill gap. The COVID-19 pandemic (P1, P3, P4) has exacerbated the gap. An intermediate level approach is often ineffective in meeting both groups' needs (P2). Sharing teaching material and concepts across schools (P4) promises higher quality with reduced work.

How to engage the students and sustain a positive classroom atmosphere are further considerations (P4). More practice time (P2–P4) and new shared, scientifically evaluated teaching and performance concepts are needed (P1, P4). Instead of memorizing and repeating (P1, P2), interdisciplinary, project-oriented, and holistic learning is suggested, including future competencies such as teamwork, creativity, and emotional intelligence (P1, P4). Digital tools are helpful if used in a subject-specific, goal-oriented, and pedagogically versed way (P1, P4). A frequent barrier is schools' technical infrastructure (P3). Long screen times are criticized for reducing attention span (P3).

Improving lesson quality involves giving students time to actively find their own solutions and focusing on applied tasks (P2). Although creative classes improve quality, they may overwhelm low-performing students and amplify math anxiety (P2, P3). This could be mitigated by consolidatory practice (P2) to increase the students' self-efficacy (P4). Carefully calibrating exams, e.g., starting with easy questions, counteracts blackouts (P3). On the other hand, applied tasks enhance the students' understanding of math's relevance (P1, P2). The students' motivation and attitude are influenced by personal responsibility (P4), and parental attitudes (P2).

Three interviewees mentioned societal issues, including stigmatization of middle schools and high performers (P4, P2), a partly critical attitude towards math, and a rising division of society (P3). Regarding the migration-related language barriers (P2, P4) and missing support for socioeconomically disadvantaged students (P1), all-day schools would be a good solution but are difficult to implement due to staff shortages (P4).

Reflecting on the role of politics, they criticized inappropriate, hasty reforms (P1), the Bologna process (P2), talking instead of taking action (P2), and limited expert involvement (P1, P4). They suggest nationwide approaches while keeping federalism (P3) and ensuring school autonomy within frameworks (P3, P4). This would prevent overly demanding standards and allow customized development and flexibility. The orientation towards future competencies of the new curriculum was positively mentioned (P3), while education standards and the G8-to-G9 transition were seen ambivalently (P3).

3.4 Results of Interviews with Scientists

The scientists agreed that the school curriculum is mostly exam-oriented with little to no focus on real-life application questions (E1–E4), whereas PISA focuses on the latter. However, the PISA assessment is seen as a reliable global marker of the decline in mathematical performance in Germany, even though it fails to assess the day-to-day learning progress of students. One suggestion was to include a criterion for assessing the student–teacher relationship as it relates to the students' interest and motivation to learn a specific subject, here mathematics (E3).

The COVID-19 pandemic (E1, E3), limited language comprehension among students with immigrant backgrounds (E1, E3), and reliance on traditional teaching methods (E1, E4) along with teacher shortages (E2, E3, E4) could be contributing to the decline in mathematical interest and performance among students in Germany. Additionally, insufficient digitalization and the inability to adapt to evolving learning environments (E2, E4) exacerbate these challenges. Overloaded curricula can overwhelm students, as the focus on quantity often overshadows quality (E3). Teaching methods frequently emphasize routine problem-solving over real-world applications, leaving students ill-prepared to connect mathematical concepts to practical scenarios (E1- E4). Furthermore, language barriers hinder students' ability to fully engage with instruction, particularly for those from immigrant backgrounds who may face difficulties integrating into society and developing essential comprehension skills (E2, E3).

To address the decline in mathematics performance in Germany, experts suggest several solutions. Modernizing teaching methods is crucial, shifting from traditional approaches that focus solely on topics to ones that emphasize understanding concepts and solving problems without fear of mistakes. This approach encourages learning through trial and error, fostering a deeper grasp of mathematical principles. Improving teaching techniques can also boost motivation among both students and teachers. Implementing project-based and creative learning methods can make mathematics more engaging and relevant, allowing students to learn from mistakes and improve their motivation. Additionally, integrating digital tools into teaching enables personalized support for students of varying abilities, accommodating both high and low performers (E2, E4). A proposed shift to four-day school weeks could provide teachers with more time to develop innovative solutions and be creative, thereby enhancing teaching quality (E3). Furthermore, language fostering programs and specific initiatives to promote mathematics can help address linguistic barriers and improve overall mathematical competence (E2).

3.5 Discussion

The stakeholders agreed on several levels, suggesting they share an understanding of the problems and factors within the debate. These problems concern the overloaded curriculum, time pressure, the pressure to perform, and outdated teaching methods. Identified factors are consistent with those found in other studies (Algani & Eshan, 2019; Borgstedt et al., 2024; Wang et al., 2023). Notably, many of these had been reported two decades ago (e.g., Papanastasiou, 2000). This suggests that the debate remains relatively unchanged and problems persist.

One reason may be the high interdependence between factors as visualized in Figure 2. Our interviewees described several vicious cycles: Students and teachers recognized poor grades as core to negative self-enforcing patterns, similar to the cycle of math anxiety (Schillinger et al., 2018). Public figures pointed out a downward spiral involving gaps in competencies and increased differentiation needs (see 3.3.). This intertwining of factors significantly complicates finding efficient solutions. Attempts to solve single factors may lead to unintended consequences or reduce effectiveness.

Another reason may be a lack of priority. In politics, education often competes with more immediate issues, such as economic growth. Similar dynamics exist in the climate debate. The EIB climate survey found that while 92% of German residents think changes are needed, only 40% feel it is a priority in the next year (European Investment Bank, 2024). This lack of political prioritization may hinder sustainable reform.

All stakeholder groups share a similar vision of ideal math lessons. They suggest more individual support, and new teaching concepts with a stronger focus on application-based or problem-solving tasks with real-life relevance. These ideas are supported by the SINUS study, which concluded that new approaches to teaching, learning, and assessment are necessary. It further found that students perceive mathematics as overly abstract and complex (Borgstedt et al., 2024). However, our teachers in training noted difficulties in reducing abstractness with higher grade levels.

The stakeholder groups differed in their focus. Scientists and political actors emphasized systemic, overarching challenges and implied solving them with structural measures such as improved teacher training and support systems for students and teachers. Teachers in training concentrated on lesson design and their working conditions. The students emphasized their personal classroom experiences. This, however, may have been reinforced by our questions. All groups except students mentioned missing teaching personnel or the teachers' lack of resources and time. Students addressed systemic issues indirectly, such as the curriculum's time

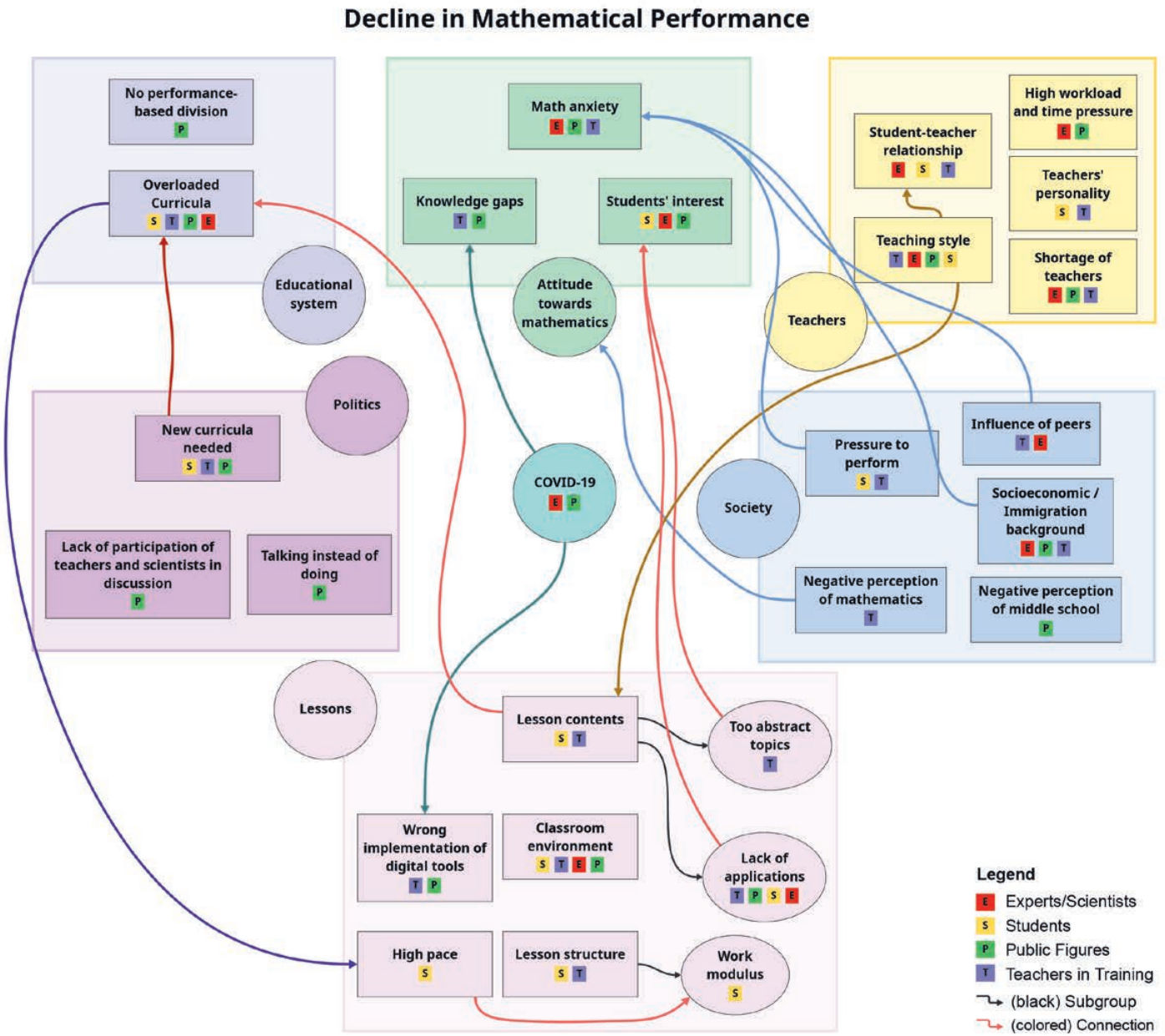


Figure 2. Situational mapping of the factors and their connections that the different stakeholders mentioned.

pressure. While the targeted use of digital tools was seen as a possible solution, students rarely mentioned it.

Both students and teachers in training stressed the importance of the student-teacher relationship and described it similarly: Teachers should show interest in their students' learning process and well-being, and be available outside of class. Both groups positively mentioned collecting students' feedback regularly and including it in the lesson planning. According to Deutsches Schulbarometer 2024, 41% are not actively asked for feedback by their teachers (Robert Bosch Stiftung, 2024). In line with studies confirming the influence of teachers (Borgstedt et al., 2024) and emotional and cognitive support (Robert Bosh Stiftung, 2024), interviewed students stressed the relationship in determining their motivation for a subject.

Our findings suggest that solutions need to target different factors simultaneously. Previous initiatives such as SINUS, EmMa, or the revised Bildungsstandards (2022) focused on isolated factors. While the current project QuaMath, meets the wish for more teacher support and further education opportunities to improve class quality, it leaves out hindering factors such as the high workload or time pressure to ensure a long-term implementation (QuaMath, 2025). The Startchancen program focuses on the financial side. It funds schools with a high percentage of socially disadvantaged students (BmBF, n.d.). In line with our interviewees' recommendations for customized solutions and school autonomy (P3, P4), schools can decide how they use the funding, such as for infrastructure.

3.6 Limitations

Our results reflect the interviewees' subjective perspectives and opinions. Thus, we do not claim to present objective factors or scientifically proven effectiveness. As opinions are dynamic, the findings represent a snapshot of the time the interviews were conducted.

Due to legal restrictions, active teachers could not be included in the data collection. Instead, teachers in training were interviewed, since they shape future education and have direct insights into school life within their internships.

A selection bias cannot be excluded, which limits the results' representativeness. Most students interviewed attended Gymnasium, enjoyed mathematics and were doing well in it. The teachers in training studied in Baden-Württemberg (N=2) or Bavaria (N=5). Statements about the structure of their programs were specific to those federal states.

4 Summary

Against the backdrop of the PISA 2022 results in mathematics, this qualitative study took an exploratory approach to investigate the perspectives of various stakeholders on the causes of declining performance of German students, and potential solutions. We conducted N=28 semi-structured interviews with students, teachers in training, scientists, and public figures between October 2024 and January 2025. We analyzed our data using a grounded-theory-based methodology. Furthermore, we used a situational mapping to analyze divergent perspectives among stakeholders.

Interviewees emphasized the need for more science-based decision-making and improved collaboration between teachers, scientists and policymakers. They also pointed to practical teaching content, innovative methods, and differentiated, tailored support for both high- and low-performing students as essential strategies. While public figures focused on systematic reforms, teachers and students emphasized classroom-level practical solutions. Overall, all stakeholders agreed on several levels, suggesting there is little controversy within the debate. The high interconnection between factors or a low priority may be the reason for why the problems within mathematical education persist. Building on this result, future research could try to understand the underlying barriers to the successful implementation of solutions, especially in the presence of stakeholder agreement.

Furthermore, further research on collaborative decision-making models or strategies to bridge differences in educational priorities could provide valuable insights for establishing more effective and practical solutions. Additionally, as highlighted in the PISA 2022 results, there is a noticeable gap between high and low performers. To address this imbalance, further research on assessment and teaching design as well as the development of enrichment programs for high performers would be essential to ensure their potential is nurtured alongside support for struggling students. Our findings point to a need for multi-dimensional, coordinated interventions instead of solutions at only the individual or systemic level.

This study provides an overarching understanding of the current debate on mathematics education in Germany. By bridging the gap between research and practice, it integrates diverse stakeholder perspectives on educational challenges. It points to a need for multi-dimensional, coordinated interventions.

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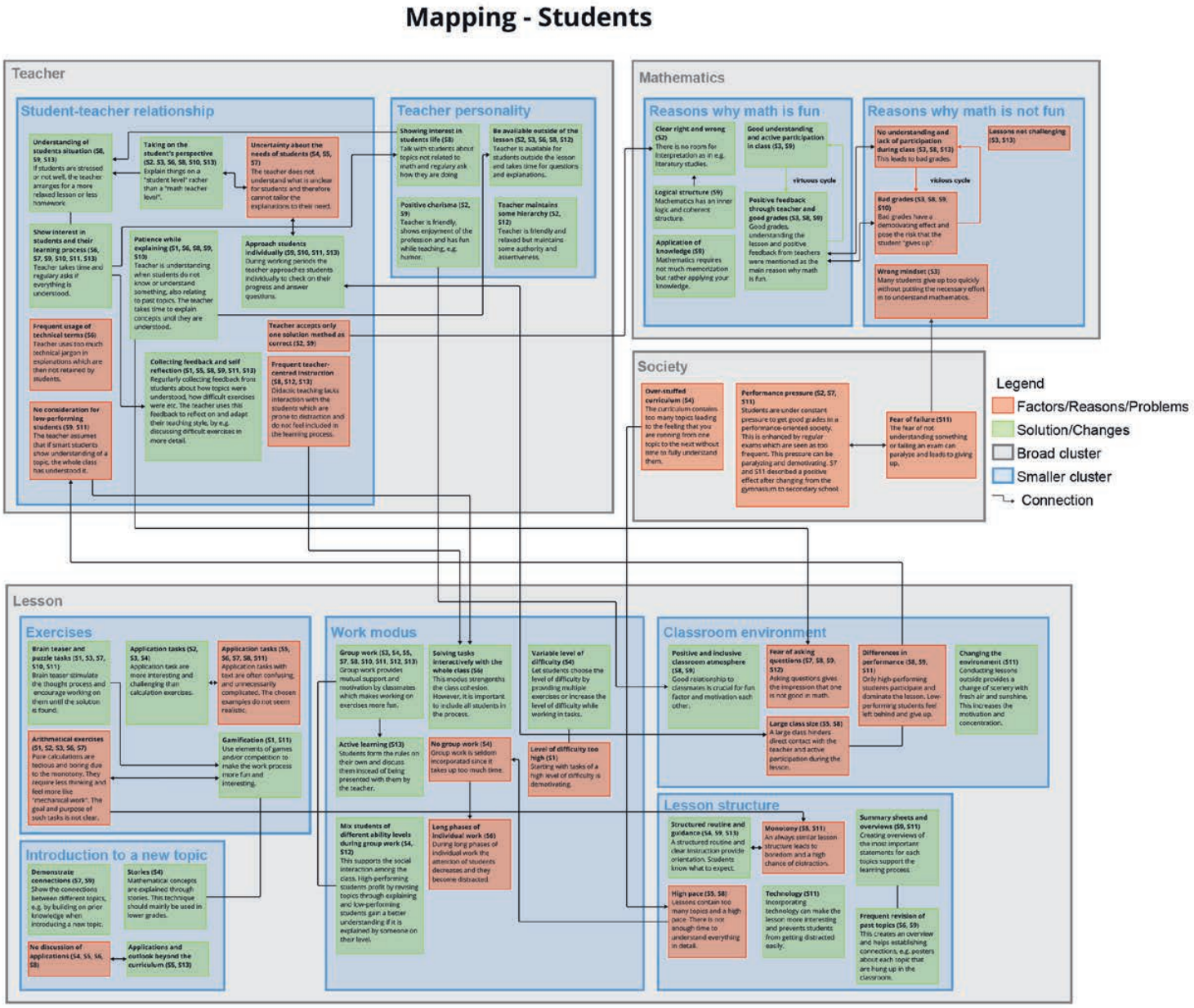


Figure 3: Mapping of factors and solutions mentioned by students

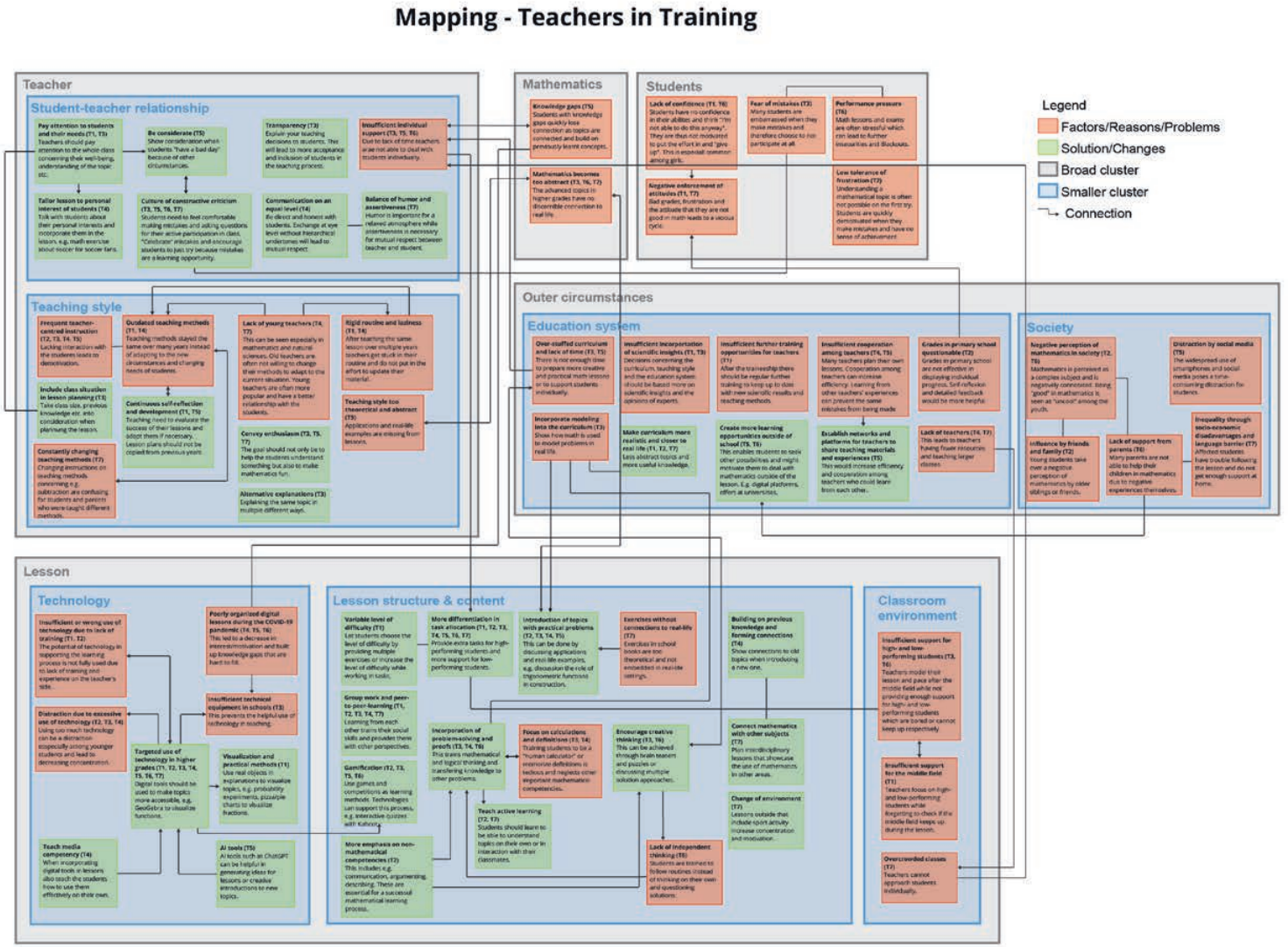


Figure 4: Mapping of factors and solutions mentioned by teachers in training.

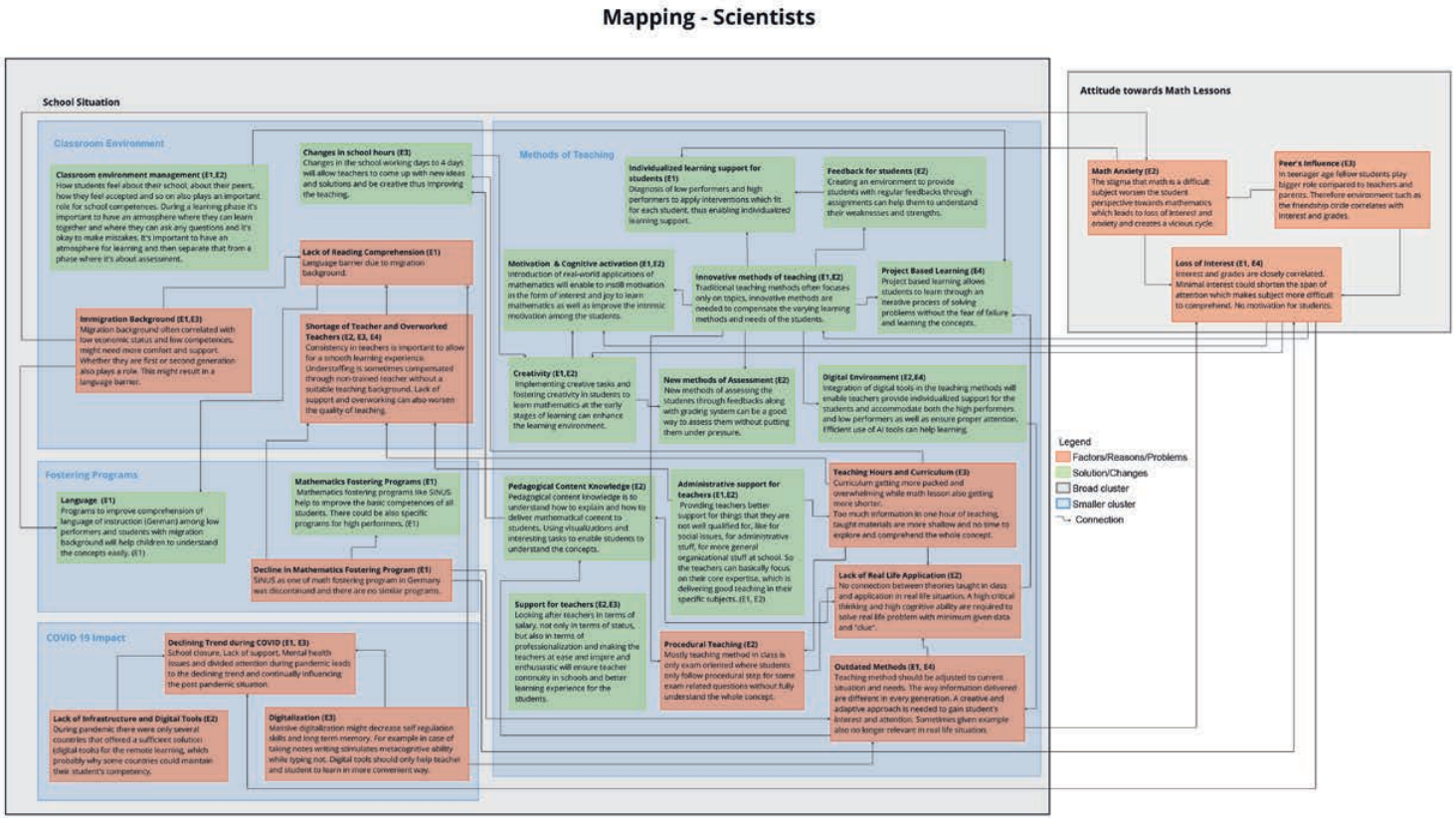


Figure 5: Mapping of factors and solutions mentioned by scientists.

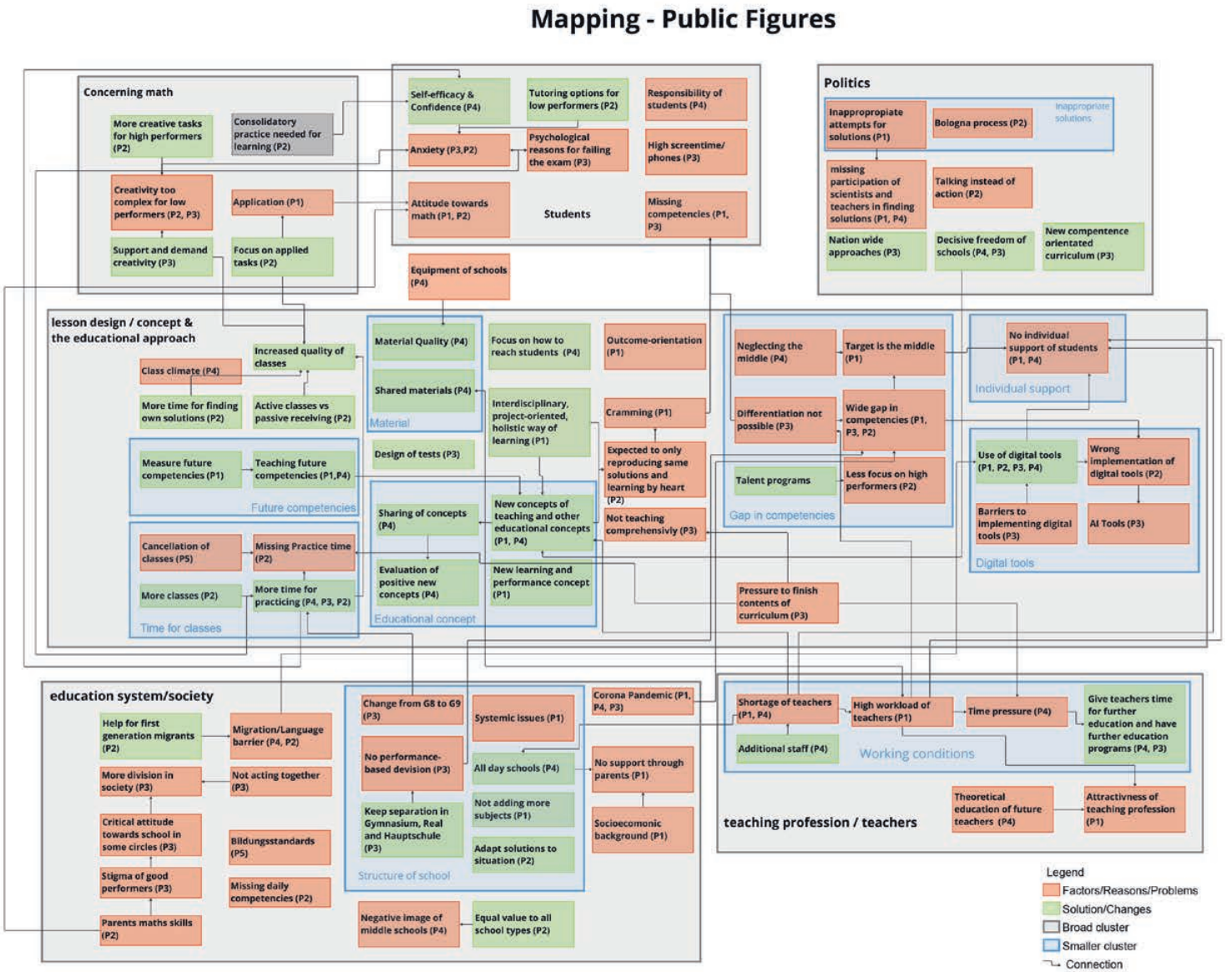
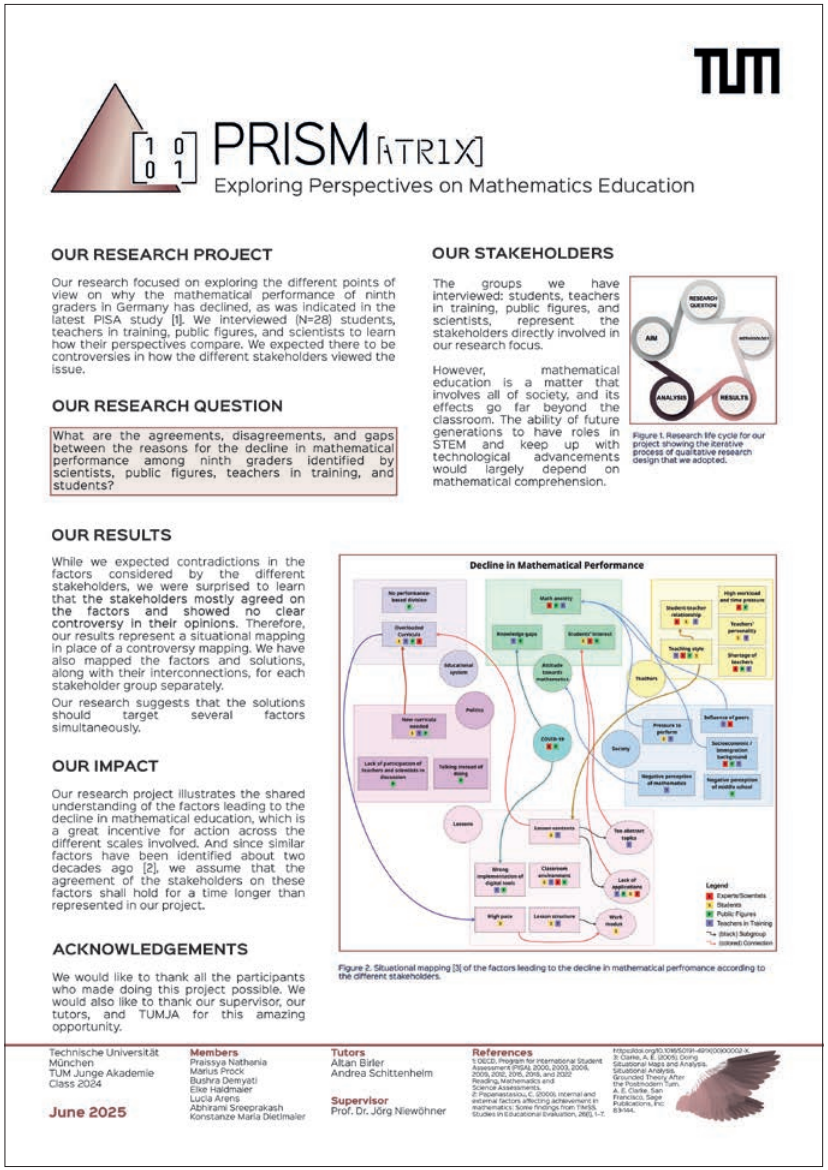


Figure 6: Mapping of factors and solutions mentioned by public figures.

Process description



PRISMATRIX

Exploring Perspectives on Mathematics Education

OUR RESEARCH PROJECT

Our research focused on exploring the different points of view on why the mathematical performance of ninth graders in Germany has declined, as was indicated in the latest PISA study [1]. We interviewed (N=28) students, teachers in training, public figures, and scientists to learn how their perspectives compare. We expected there to be controversies in how the different stakeholders viewed the issue.

OUR RESEARCH QUESTION

What are the agreements, disagreements, and gaps between the reasons for the decline in mathematical performance among ninth graders identified by scientists, public figures, teachers in training, and students?

OUR STAKEHOLDERS

The groups we have interviewed: students, teachers in training, public figures, and scientists, represent the stakeholders directly involved in our research focus.

However, mathematical education is a matter that involves all of society, and its effects go far beyond the classroom. The ability of future generations to have roles in STEM and keep up with technological advancements would largely depend on mathematical comprehension.

Figure 1. Research life cycle for our project showing the iterative process of qualitative research design that we adopted.

OUR RESULTS

While we expected contradictions in the factors considered by the different stakeholders, we were surprised to learn that the stakeholders mostly agreed on the factors and showed no clear controversy in their opinions. Therefore, our results represent a situational mapping in place of a controversy mapping. We have also mapped the factors and solutions, along with their interconnections, for each stakeholder group separately.

Our research suggests that the solutions should target several factors simultaneously.

Figure 2. Situational mapping [3] of the factors leading to the decline in mathematical performance according to the different stakeholders.

OUR IMPACT

Our research project illustrates the shared understanding of the factors leading to the decline in mathematical education, which is a great incentive for action across the different scales involved. And since similar factors have been identified about two decades ago [2], we assume that the agreement of the stakeholders on these factors shall hold for a time longer than represented in our project.

ACKNOWLEDGEMENTS

We would like to thank all the participants who made doing this project possible. We would also like to thank our supervisor, our tutors, and TUMJA for this amazing opportunity.

Technische Universität München
TUM Junge Akademie
Class 2024

June 2025

Members
Praissya Nathania
Marius Prock
Bushra Demyati
Elke Haidmaier
Lucia Arens
Abhirami Sreeprakash
Konstanze Maria Dietlmaier

Tutors
Altan Birler
Andrea Schittenhelm

Supervisor
Prof. Dr. Jörg Niewöhner

References
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Recognizing the pivotal role of lifelong learning and creativity in human life, our team initially aimed to foster creativity among working adults. In the early stages, we met to design a project around this idea. However, following the release of PISA 2022 in late 2023, which revealed a significant decline in German students' mathematics scores, we felt the urge to shift our focus and investigate the contributing factors behind this decline. We wanted to get a more personal-level view of the issue to supplement the already existing large-scale proposals for improvement. Our team aimed to identify these factors using a qualitative, exploratory approach. Over six months, we designed, conducted, and analyzed semi-structured interviews with different stakeholders. Depending on the stage of the project, our team members adapted their roles and timeframes. Based on the gathered insights, we hoped to visualize connections between problems and solutions from the perspective of different stakeholders.

In contrast to many studies focusing on the influence of different factors, we concentrated on identifying agreements, disagreements, and gaps among stakeholders. Our main challenge was recruiting interview participants. Due to legal restrictions, we were not permitted to contact public schools or interview teachers employed at state schools. Instead, we interviewed teachers in training and students through private contacts. After completing all interviews in January 2025, we finalized our coding process with the support of our supervisor and tutors. Based on the qualitative analysis, we visualized key themes and created mappings. In the final step, we compared these mappings, concluding that all stakeholders agree on the main problems in math education. ■

Self-Reflection PRISMatrix

Our interdisciplinary research team, PRISMatrix, came together in October 2023 with the shared goal of investigating the perceived causes of the mathematical decline among students in Bavaria. Our members came from varied academic backgrounds, which shaped the way we approached our project and the team dynamic as a whole.

From the beginning, we discussed what each of us is most interested in. It's certainly true to say that each member learned something new, expanded their knowledge in various areas, and got to experience aspects of research that would have otherwise been difficult to experience. Our supervisor was very helpful in guiding our process and filling any gaps in our knowledge.

The team atmosphere remained collaborative and fun even in the slower phases. We tried to meet in person as often as possible, and our meetings were always filled with stories, jokes, and, of course, lots of snacks. Our tutors were also very supportive and friendly throughout the whole process: we have quite a few inside jokes with them at this point.

The interviewing process was also new for all of us. We had the chance to conduct interviews with people of different ages, academic backgrounds, and social stations. The project is special to us because of the friendships we formed. The weekends we spent together weren't just productive - they were also very engaging! Whether it was joking around with our tutors and other scholarship holders or sharing meals after long work sessions, a sense of camaraderie developed. This was very much reflected in how we worked on the project. While PRISMatrix was a one-time collaboration, it was a meaningful and enriching experience for all of us, and one we'll carry in our future academic and professional journeys. ■


BEAR WIDOW


TikTok

Research Report **windfo**

Germany's scientific output is massive – but how much of it reaches the public? In a time dominated by social media and increasing misinformation, effective science communication is more crucial than ever. Our research group windfo, part of TUMJA #class24, explored how scientists can use short-form videos to communicate complex topics like wind energy – efficiently and credibly. The results are clear: Authenticity beats perfection, AI can ease production, and it's time for researchers to step into the spotlight.

Team	Debora Baumann Camila Bustos Martina Casas Infante Nicole Fritsch Eric Jacob Annemarie Weibel
Tutors	Andrei Costinescu Alesia Prendi
Supervisor	Prof. Dr. Gisela Detrell

Preface by the Supervisor

Prof. Dr. Gisela Detrell

The windfo project addresses a highly complex and highly relevant question of our time: How can scientific information be shared on social media in ways that preserve credibility and promote learning? In an environment increasingly shaped by artificial intelligence, the team explored how different forms of content production – human-generated versus AI-generated – impact trust, attention, and information retention.

The students designed and conducted a comprehensive experiment, creating a series of short informational videos about wind energy. Each video varied in key aspects such as speaker type (human vs. AI), presentation style (lecture, interview, explainer), and visual design (real footage vs. AI imagery). Specific misinformation elements were deliberately embedded to assess participants' critical evaluation skills.

By collecting and analyzing data from over 400 participants, Team windfo provided valuable insights into how format and production choices influence audience perceptions. Their results show that while AI-generated visuals can be well accepted, human voices and visible presenters significantly enhance trust in the conveyed information.

windfo

Throughout the entire process, the team demonstrated a high level of independence, creativity, and professionalism. It was a pleasure to meet them in person at the very beginning, when the project idea was still evolving, and now, reading their final report, it is really impressive to see how far they have come.

I am confident that they have not only gained valuable insights into the impact of AI-generated versus human-created content but have also developed essential skills in conducting methodical research, working collaboratively, and overcoming challenges.

Congratulations on your outstanding achievement, and all the best for your future endeavors!

Supervisor Insights

What is your research interest or motivation for science?
I am fascinated by the challenge of enabling sustainable human presence in extreme environments, such as space. My motivation is to develop innovative technologies that not only advance human exploration but also have tangible benefits for life on Earth.

What special experience from your studies/career would you like to share with the scholars?
During my career, I have often experienced that the most valuable ideas came from interdisciplinary teamwork. I encourage young researchers to stay open-minded and collaborate beyond the boundaries of their specific fields.

Between Lab Coat and Like Button

Why Scientists Should Embrace Social Media

Germany is home to more than 430.000 researchers, who in 2020 published over 174.000 scientific papers to document and share their recent advances, from natural to social sciences. However, listening to socio-political debates with friends or even family or – even more striking – scrolling through comment sections on Social Media might cause one to wonder whether all that research has ever reached the general public in the last twenty years or more.

But instead of simply repeating what is known, it is time to change something. That is why we want to appeal to scientists and researchers from all fields and disciplines: Communicate your work – and be more courageous doing so!

Now, before you stop reading, telling yourself that you do not have the time or money, let us address the elephant in the room: Yes, high-quality science communication requires time and effort – two resources not known to be abundant among university employees – and it is not necessarily easy to fit in between doing the actual research, teaching obligations and administrative duties.

Nonetheless, we argue that maintaining a social media presence and allocating resources to science communication, even in a rather basic format, is a crucial step towards increasing knowledge among the public and regaining trust in science and in a democracy that every scientist should consider themselves to be a part of.

Sure, many fields of science require a high level of in-depth knowledge for one to even begin to understand recent breakthroughs, let alone their implications and relevance. There may also be fields of research that are less relevant to the primary issues we currently face in the world. Nevertheless, the amount of misinformation that plagues our public discourse is astonishingly high – from climate denial to revisionist history – and a high number of people are still falling for it. In the long run, this will put our democratic system at risk, as can already be seen by the recent developments across the Atlantic, but also right here in Germany, where non-issues have been blown up to looming threats, causing a shift in the priorities that are set on the political agenda.

As part of TUMJA #class24, we, as the research group windfo, spent the last 20 months researching how science communication on Social Media can be done in a way that not only retains a high level of trust and interest among viewers but is also efficient to produce for scientists. Due to the rise in popularity of apps like TikTok, we have focused on short-form video content in particular, creating eight different videos on the exemplary topic of wind energy ourselves and analyzing how they are perceived by a general audience.

Our analysis shows a clear result: Scientists should be more courageous in producing social media videos! Our research shows that fully human-made videos perform only slightly better than AI-generated or AI-voice-over videos in terms of trust and retention. This suggests that AI can significantly reduce the workload for scientists without compromising effectiveness. By using AI tools for scripting, voiceovers, or even basic video editing, researchers can focus on delivering high-quality content without investing excessive time in production, making science communication more accessible and scalable.

At the same time, comprehension is not significantly affected by the choice of video format. However, specific formats, such as self-interviews (a comedic style of video in which one person acts as both ends of a conversation) and real imagery of places and events that is not AI-generated, enhance trust and engagement, while simply reading information aloud does not have the desired effect. Scientists do not need to worry excessively about perfect production quality – authenticity matters more. Researchers can effectively communicate their findings by incorporating relatable and visually engaging formats while retaining audience trust.

Sharing knowledge on social media can foster a more informed society. People who consume science-based content are more likely to make educated decisions in their daily lives, whether in areas such as health, energy consumption, or environmental protection. As Christian Drosten once noted in a podcast episode of *Jung & Naiv,* "You can't spend 20 years doing taxpayer-funded research and then just back out when things get tough" ("Virologe Christian Drosten über die Lehren aus der Pandemie – Jung & Naiv" (2025, März 5): Folge 744. YouTube. https://www.youtube.com/watch?v=av2Hax3Bg1U, at 15:45 mins, translated from German)) Contributing to public discourse through social media can be seen as a modern extension of this duty, ensuring that scientific insights reach beyond academic circles and influence meaningful change.

Social media is increasingly used for information, not just entertainment. Scientists do not need to be afraid of producing self-made videos. When incorporating personal presence and real imagery and utilizing quicker cuts, audiences enjoy the content, comprehend it, and retain the information better. While publishing research

in journals remains essential, communicating findings to the general public helps bridge the gap between science and society. In an era where misinformation spreads rapidly, actively engaging in science communication can empower people to make more informed decisions and strengthen democratic discourse, and should thus not be neglected by researchers. ■

Research Report – windfo

Science Communication on Social Media: Scientists should be more courageous!

Table of contents:

Abstract

Social media offers valuable opportunities for public engagement and enables interaction between scientists and the general public. Our research project “windfo” investigates how different types of short videos influence trust, liking, comprehensibility, and retention in the context of science communication about wind energy. The study was conducted using an online survey that included one video and corresponding questions addressing the target variables. The videos varied in elements such as clipping speed and whether the content was AI-generated. While AI-generated videos offer efficiency, human elements were associated with higher levels of trust. Liking and retention were significantly influenced by gender and age, whereas comprehensibility did not differ significantly between conditions. Certain limitations, such as the controlled study setting and topic-specific variability, must be acknowledged. Nevertheless, the results suggest that valuable science communication content can be created for social media without needing to overemphasize specific video formats.

1. Introduction

“Nothing in science has any value to society if it is not communicated.” Despite being said by Anne Roe in 1952, this quote remains highly relevant to this day. Today, social media plays a major role in shaping public discourse, with platforms like X, Instagram, and Facebook generating millions of interactions per minute (Statista 2025a, 2025b). Nearly 80% of Germans use social networks actively, making these platforms powerful channels for science communication.

Social media, according to *apomediation theory*, allows direct, unmediated interaction between scientists and the public (O'Connor 2013; Regenberg 2019). However, this benefit can also pose challenges: content shared briefly and without context can lead to misinterpretations (Roland et al. 2015), and the spread of misinformation or “fake news” remains a serious concern (Majerczak & Strzelecki 2022).

Generative AI adds to this complexity. While it enables faster content creation, it also raises concerns about authenticity, accura-

cy, and transparency—essential values in science communication (Open Science Future 2024). Studies suggest that better explainability and accountability in AI can foster trust, but this depends on how well communicators are trained to use these tools (Shin et al. 2022).

Despite increasing use of digital media, users still lack adequate media literacy and resistance to misinformation (Majerczak & Strzelecki 2022; Trninić et al. 2022). However, there is limited research on what influences trust and awareness in science-related content on social media.

To address this gap, we conducted an experiment to measure how different video formats affect the viewer's liking, trust, comprehension and retention. We created eight social-media-style informational videos on wind power, each varying by one key feature, while keeping other variables constant. Wind power was chosen as an exemplary topic due to its relevance and controversy in Bavaria (Clean Energy Wire 2023), and each video intentionally included three pieces of misinformation to test audience comprehension.

The videos produced in German to reach a broad Bavarian demographic, were assessed via a digital survey. Our goal was to identify which formats best support effective science communication and to provide practical guidelines for researchers aiming to use social video content in their outreach.

We focused on four core criteria: liking (personal enjoyment of the video), trust (perceived reliability of the content or presenter), comprehension (understanding of the messages within the video), and retention (how well viewers remember the content). Attention was also key, as engagement is essential for effective information transfer. By analyzing audience responses across demographics and video types, we hope to inform better practices for using social media in science communication.

Based on the theoretical framework and prior research, we propose the following hypotheses:

Trustworthiness Hypotheses: We hypothesize that perceptions of trustworthiness vary depending on the video format and the source of the visual and auditory content. Specifically, we expect that AI-generated visuals and voice-overs will be perceived as less trustworthy than human-generated visuals and voices. Additionally, we hypothesize that the format and degree of editing will influence perceived trustworthiness.

Retention Hypotheses: We further hypothesize that information retention is influenced by the source of the video and voice production, as well as by the video format. We hypothesize that retention scores are higher for human-generated videos compared to AI-generated ones. Specifically, we compared visuals and audio.

Liking and Trust were only compared between the different video styles to see whether any significant differences would arise between them.

Influencing Variables Hypothesis:
We hypothesize that individual differences, particularly age, gender, and amount of social media usage, will moderate the effects of video format and content production method on perceived trustworthiness and retention.

Research Objective: By testing these hypotheses, we aim to assess the extent to which trustworthiness and information retention are affected by variations in the presentation format, production method (AI vs. human), visual editing, and language style in short videos discussing the topic of wind power.

2. Materials & Methods

2.1 Study design

The following sections provide an in-depth description of the videos and the survey developed during our research. This study employs a quantitative, cross-sectional, and retrospective design to analyze participants' perceptions of trustworthiness and information retention. Data were collected through a structured survey, with questions before and after one of our eight videos being shown to the participants.

2.1.1 The Videos

Before filming, we prepared a script. We used the script uniformly across all videos to minimize variations in perception caused by differences in wording, with an exception for video 2 (Self-interview), due to its different setup (two people talking to each other). The full script can be found here: tiny.cc/windfo-script.

We designed the script to be informational, educational, and short (90 seconds), due to most social media platforms' limitations on video length (most commonly 60 or 90 seconds). It presents relevant facts about wind power plants and their challenges clearly and concisely. As mentioned above, we deliberately embedded three pieces of misinformation in our script, to analyze trustworthiness. All of the videos can be found at tiny.cc/windfo-videos.

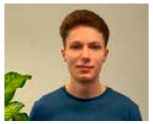
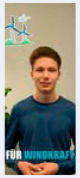
2.1.2 The Constants

We tried to keep as many constants as possible throughout the videos to avoid unexpected external variables, e.g. differences in clothing. The constants between the videos are the following:

- **Script:** All videos use the same wording and content, except for video 2 (Self-interview), as presented above.
- **Duration:** All videos are between 80 and 90 seconds long, as is standard for social media.
- **Speaker:** The same individual appears in all videos where a person is visible.
- **Format:** All videos are in portrait orientation, as is standard for social media.
- **Wardrobe:** The speaker wears a dark-blue long-sleeve top.
- **Voice:** The speaker maintains a similar speed, tone, and enthusiasm across all videos.
- **Equipment:** All videos use the camera model Sony Alpha 6400 and microphone model RØDE Wireless Go, except for videos 6, 7 and 8, for which the visuals (7, 8) and audio (6, 8) were generated by GenmoAI and Invideo.

2.1.3 The Variables

	Location	Style	Interaction with audience	Audio	Editing	Filming	Notes
Video 1 Lecture 	In front of a board inside the lecture hall	Speaker talks to the students in front of them, camera image starting from the waist up including the arms, relatively static picture	Speaks indirectly into the camera; looks at students instead of at the camera	Live, from speaker	Minimal, no/ few cuts, no overlaid text/ graphics	Medium shot portrait format	Low effort filming, clear monologue, no extra add-ons
Video 2 Interview 	Calm background on a sofa in an office, some plants in the background	Two characters (same person, dressed slightly differently) talk to each other in a dialogue, only one character is seen at a time. Shot switches between characters as they talk	Speakers do not talk/look directly into the camera; their attention is on the other person	Live, from speakers	Cuts between the two people so they are in frame whenever they speak, no visual overlays	At 45° and each person constantly either left or right side ➜ medium close-up	Higher effort, more editing, two parts of the dialogue need to be filmed separately in different angles

	Location	Style	Interaction with audience	Audio	Editing	Filming	Notes
Video 3 Explainer 	Office, plain background, a plant for decoration	Speaker talks directly into camera, plain monologue	Speaker talks to audience, hand gestures, plain monologue	Live, from speaker	Minimal, few cuts, no overlaid text or graphics	Medium shot	Some space is intentionally left to add graphics and text in video 4
Video 4 Explainer with visuals 	Identical to video 3	Identical to video 3 + overlaid text and graphics for visual support	Identical to video 3	Identical to video 3	Overlaid text and graphics have to be edited in for visual support	Identical to video 3	Video 4 is made with the footage of video 3 + overlaid text and graphics
Video 5 Human / Human 	Wind Power plant, solar panel plant, nature, outdoors	Documentary style: Filmed footage and different shots (no AI-generated footage), no speaker visible, maybe some animations	Speaker talks to the audience, but is not visible	Human voice-over (recorded, not AI-generated)	Different shots need to be edited together, text overlays and graphics where useful	Several shots and footage of wind power plants, workers, solar panels, birds, motors	A documentary style video, high effort, different shots need to be filmed and edited
Video 6 Human / AI 	Identical to video 5	Identical to video 5	Identical to video 5	AI-generated voice-over	Identical to video 5	Identical to video 5	Video 5 with AI voice-over instead of human voice-over
Video 7 AI / Human 	-	Documentary style, only AI-generated imagery, no live video, no speaker visible	Speaker talks to audience, but is not visible	Human voice-over (recorded, not AI generated)	AI-generated changing imagery	No filming needed (AI)	Low effort, AI creates and edits most of the footage
Video 8 AI / AI 	-	Identical to video 7	Identical to video 7	AI-generated voice-over	Identical to video 7	Identical to video 7	Video 7 with AI voice-over instead of human voice-over

2.1.4 The Filming Process
The filming took place over two days. On day one, we recorded videos 1-4 at the TUMJA office and an empty lecture hall at TUM. On day two, we traveled to Denklingen Windpark to film videos 6 and 7 in various locations.

2.1.5 The Survey
We created the survey to measure our four evaluation criteria, liking, trust, comprehension and retention, across our different videos and different demographics of the participants and to answer our initial hypotheses. Like the videos, the survey was conducted in German and took around seven minutes to complete, including watching the 90-second video.

To measure the evaluation criteria of the videos, we embedded one of our videos in the middle of the survey for our participants to watch and then answer questions about their perception of the video. We used an algorithm that randomly selected one of the eight videos for each participant.

The survey, was structured in three parts:
1. Part one was designed to determine **decisive demographics**, e.g. gender, age, and education, as well as the participant's usage of and attitude towards social media.
2. Part two included the randomly selected video as well as some general questions about its **perception**, regarding e.g. video speed, familiarity with the topic, and clarity of contents.
3. Part three measured the three **evaluation criteria** with Yes/No questions, such as "I believe the information conveyed to be factually correct," "I was attentive following the video during this survey" and questions about the content of the video, e.g. "How much renewable energy is Germany set out to produce in 2030?".

The survey included different types of questions, all designed to enable a quantitative analysis. These included categorical questions, such as selecting an educational degree, and Likert scale questions, where participants rated statements (e.g., "I was attentive following the video during this survey") on a scale from 1 (not attentive) to 5 (very attentive).

The entire questionnaire can be found here: tiny.cc/windfo-questions.

2.2 Data Collection
We collected data from 10th of November to 17th of December 2024. The survey participants were acquired via:

- Sharing the survey link online through social platforms including LinkedIn, WhatsApp, direct messages, mailing lists, and Instagram stories.
- Street surveys, where we asked people in public places to scan a QR code and complete the survey.
- Instagram Ads, played by the @tum.jungeakademie account:
- The first ad reached 31,958 accounts and led to 458 clicks on the survey
- The second ad reached 22,667 accounts and led to 546 clicks on the survey
- The ads ran from the 30th of November to the 16th of December

It is worth noting that women were more likely to participate in the street survey than men, which corresponds with the research of W.G. Smith (2008), who found that while women were more likely to participate in surveys, yet there was no gender bias.

Data collection was conducted under GDPR compliance, as agreed to by the participants of the survey.

2.4 Timeline
Fig.1 shows our research timeline. It can be broken down into three phases: The planning and research phase, the execution phase, and the analysis phase. The planning and research phase from March 2024 to June 2024 included all the literature research we did before starting our project as well as detailed planning of the

filming process and data collection. We began the execution phase at the end of June 2024 with workshops on video scripting, filming, and cutting. All videos were finalized in August 2024. The data collection occurred from October to December 2024. This included sharing our survey through online platforms, street surveys and Instagram ads. We began the analysis phase in 2025. This included the data analysis and discussion as well as the development of our social media guidelines for scientists.

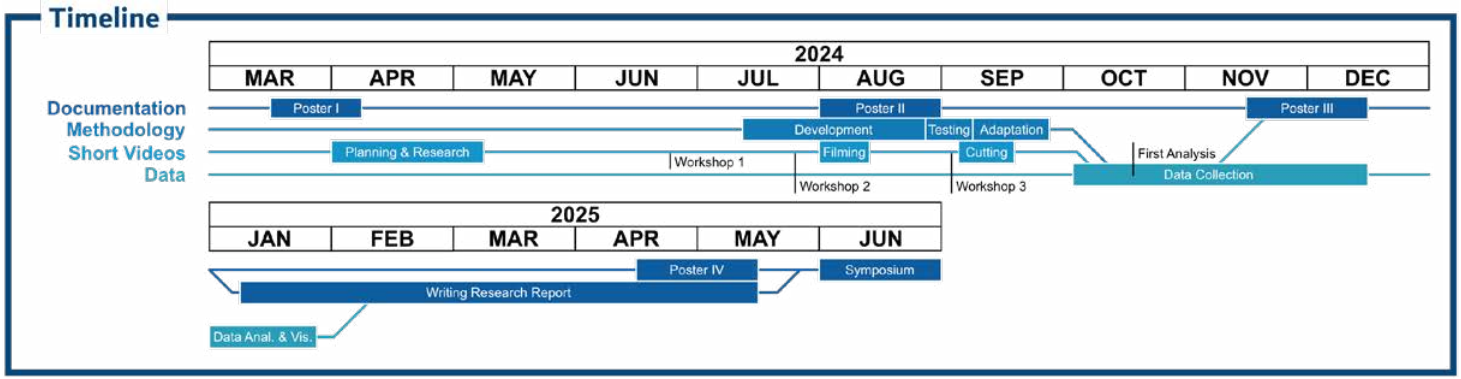


Fig.1 Research Timeline of the windfo project

2.5 Analysis

As is common practice to estimate the sample size, a G*Power analysis was conducted for a multi-factor ANOVA using a medium effect size, an alpha level of 0.05, and a power of 0.80, following standard guidelines (Cohen, 1988). Our data collection achieved the required total sample size of 400 participants, with 50 per group, as indicated by the G*Power analysis.

We conducted the data analysis using the statistical software R Studio. Observations are uncorrelated by the cross-sectional study design via a survey. The normal distribution assumption for the underlying datasets was assumed as sample size for groups were > 35. We ensured homoscedasticity using the Levene-test. After initial descriptive statistics, we analyzed the four major constructs: comprehensibility, trust, retention and liking of the video. These latent variables were assessed by the test person's subjective survey response to certain questions.

Comprehensibility was assessed by the people subjectively answering on how easy the video was to understand in terms of talking speed, the content of the video in general and the wording. The variable trust was measured by questions on perceived trustworthiness towards the speaker and the video itself on a scale from one to four. Retention was measured by a small multiple-choice test within the survey, containing five questions on the videos' content. The last latent variable that we assessed was how much people liked the video by asking how the people liked the video style, the topic, and whether they would want to watch videos like this in the future.

The hypothesis on a different predictive value of the videos on trust, retention, liking and comprehensibility were analyzed with a multiple ANOVA, while controlling for quantity of Social Media usage, age and gender. Additionally, differences between human and AI-generated video and voice were assessed by a one-tailed t-test, suggesting that trust, retention, liking, and comprehensibility are higher for human creations. To identify differences in the latent variables between videos, we conducted post-hoc tests after Tukey's HSD and corrections by Bonferroni-Holm. In the present analysis, participants who identified as diverse (N = 9) were excluded from tests on gender differences due to the small sample size. Given the limited number of cases, meaningful statistical comparisons could not be conducted, as small groups can lead to violations of statistical assumptions and reduced statistical power.

3. Results

3.1 Study Population

The 441 participants in the final sample had a mean age of 34.69 years (SD = 14.86). The age distribution can be found in Fig.2. 274 out of the total sample size were female, 158 male, and 9 diverse.

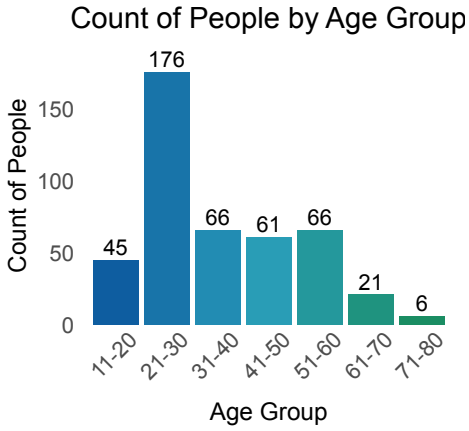


Fig. 2 Count of People by Age Group

All videos had 55 or 56 views.

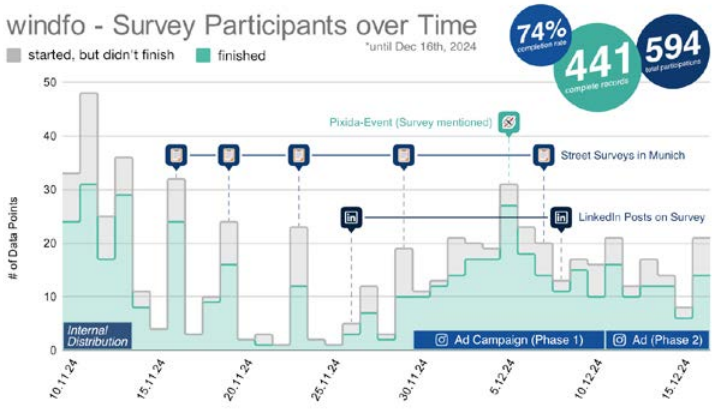


Fig. 3 Survey Participation over time

3.2 Trust

A two-way analysis of variance (ANOVA) was conducted to examine the effects of video type, age, and gender on Trust.

The analysis revealed a significant main effect of video type on trust ($F(7, 176) = 3.099$, $p = 0.004$, $\eta^2 = 0.11$). Post-hoc tests after Tukey's HSD showed significant differences for trust by video type for video 2 and 6 ($p = 0.035$, $d = 0.42$), 2 and 8 ($p = 0.01$, $d = 0.49$), 5 and 8 ($p = 0.03$, $d = 0.51$). No significant main effect between male and female gender on trust was found. Additionally, age did not show a significant main effect on trust. No significant interaction effects were observed.

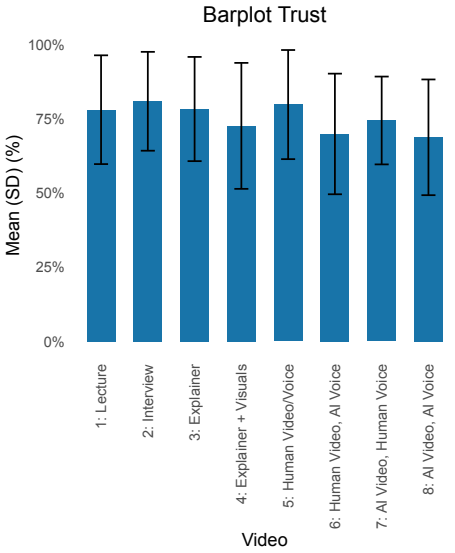


Fig. 4 Effects of Video Type on Trust

Additionally, we performed an analysis for differences in human or AI created material on trust scores. The t-test comparing AI Video (7 and 8) to Human Video (5 and 6) showed no significant difference in trust scores ($p = 0.19$). The t-test comparing AI Voice (6 and 8) to Human Voice (5 and 7) showed a significant difference in trust scores ($p < 0.01$) with Human Voice having a higher mean trust score.

windfo

3.3 Liking

A two-way ANOVA was conducted to assess the impact of video type, age, and gender on liking. The results showed no significant main effect of video type. However, there was a significant main effect of gender on liking ($F(2, 176) = 3.262$, $p = 0.041$, $\eta^2 = 0.04$). The post-hoc test by Bonferroni-Holm showed a significant difference for liking between male and female subjects ($p = 0.028$, $d = 0.26$)

Furthermore, a significant main effect of age on liking was found ($F(6, 176) = 2.284$, $p = 0.038$, $\eta^2 = 0.07$). No significant effects by age on liking were found in direct group comparisons with Tukey's HSD.

No significant interaction effects were observed.

3.4 Comprehensibility

The ANOVA for Comprehensibility did not yield any significant main effects or interaction effects.

3.5 Retention

A two-way ANOVA was performed to investigate the influence of video type, gender, and age on retention. The results indicated no significant main effect of video type. However, there was a significant main effect of gender ($F(2, 176) = 4.697$, $p = 0.010$, $\eta^2 = 0.05$). Post-hoc test with correction after Bonferroni-Holm showed a higher retention score for male participants ($p = 0.01$, $d = 0.29$).

Additionally, age showed a significant main effect, $F(6, 176) = 2.829$, $p = 0.012$, $\eta^2 = 0.09$). Post-Hoc tests with correction by Tukey's HSD revealed a significant difference for the age groups 21-30 and 61-80 ($p = 0.01$, $d = 0.32$). Other comparisons between age groups were not statistically significant ($p > 0.05$).

No significant interaction effects were found.

Additionally, we performed an analysis for differences in human or AI-created material on retention scores. The Welch Two Sample t-test comparing AI Video (7 and 8) to Human Video (5 and 6) showed no significant difference in retention scores ($p = 0.4305$). The Welch Two Sample t-test comparing AI Voice (6 and 8) to Human Voice (5 and 7) showed no significant difference in retention scores ($p = 0.55$).

4. Discussion

In the following sections, we examine our study's findings based on these criteria. Our study analyzed video formats commonly found on social media to ensure our results translate to practical recommendations for researchers producing scientific videos. Additionally, we evaluate how viewer characteristics, such as gender and age, influence the audience's experience and perception of the videos.

4.1 Trust

Our ANOVA analysis indicates that **video type** – the format through which content is presented – significantly influences viewers' trust in the video. While the effect on **trustworthiness** is moderate, the choice of video format remains crucial. **Gender** also has a significant impact on trust ratings, with an effect size comparable to that of video type. However, no interaction effect was found, meaning that the influence of video type on trust is independent of age and gender, and vice versa.

To compare individual videos, **Cohen's d** was used to measure effect size. **Video 2 (Self-Interview)** was rated as significantly more trustworthy than **Video 6 (Real Imagery + AI Voice)** and **Video 8 (AI Imagery + AI Voice)**. This suggests that videos featuring a real person speaking in an interview format foster greater trust than those relying on AI-generated content. Consistent with previous research (Buchanan & Hickman, 2024), our findings indicate that people generally trust human-made content more. Additionally, **Video 6 (Real Imagery + AI Voice)** was rated as significantly more trustworthy than Video **8 (AI Imagery + AI Voice)**, reinforcing the idea that an increased presence of AI reduces perceived trustworthiness.

Interestingly, no significant difference in trust was observed when comparing **Video 5 (Real Imagery + Human Voice)** with AI-enhanced videos. Nevertheless, across all comparisons, videos incorporating AI received lower trust ratings overall. These findings suggest that using **real imagery, voices, or human presenters** is more effective in fostering trust. One possible explanation is that natural human voices may be perceived as more credible, relatable, and engaging than synthetic AI-generated voices.

While AI-generated content is a practical solution when resources are limited, these results suggest that incorporating human elements where possible enhances trustworthiness.

4.2 Liking

The next criterion, liking, had a much smaller impact on how much people enjoyed watching the video presented. But when comparing differences between genders, women, on average, rated the videos lower in terms of liking than men. It should be noted that the presenter in the videos with a person in front of the camera was a man in his twenties. This may influence the relatability between the viewer and presenter – an implicit bias that has often been observed in the literature, where older people are perceived more knowledgeable and competent than their younger counterparts (Nath et al., 2006). Additionally, it is possible that women answered the questions more critically and were more engaged in providing good feedback for the survey.

4.3 Comprehension

The video format did not significantly impact how people comprehend the presented information. Additionally, the demographic characteristics of the viewer did not affect the amount of knowledge gained either. This suggests that all video formats were equally effective in delivering comprehensible information, meaning AI-generated and human-produced videos worked similarly well from an educational perspective. Since the information was shared with a similar text in all videos, it is possible that a different type of text would have impacted comprehension. The text was written in a way that avoids complicated sentences and tries to simplify complex content, without oversimplifying (and potentially misrepresenting) causal connections. This seems to be more important than the way of presenting the information.

4.4 Retention

The retention of the viewer was tested by deliberately including wrong facts in the videos. This was done to prevent the audience from using prior knowledge in answering the follow-up survey questions. The video format did not influence how much information participants retained. This suggests that AI-generated videos can be as effective as traditional human-led formats for memory retention. Like the differences in the liking criteria, women, on average, retained less information than men. The difference is small but might support a societal difference in ascribed or actual knowledge of technical topics like wind energy production (Stewart-Williams & Halsey, 2021).

Similar to liking, age affects the retention level. Older participants (61-70) retained more pieces of information than younger ones (21-30) ($p = 0.011$, $d = 0.32$). This suggests that older adults performed better in remembering the content, which could be due to differences in experience and exposure to short-form video formats. Yet, it should be noted that our sample size in data points is a lot smaller for people of the older age group than for younger ones, which might hint towards a statistical outlier. It is also possible that the survey setting impacted this outcome. Older participants might have taken more time, more focus, and a more serious attitude when participating in the survey. Younger participants might not have focused with the same amount of headspace (as might also be more realistic when it comes to using social media platforms in their everyday life).

The analysis revealed no significant effect of video type on Liking, Retention, or Comprehensibility, indicating that AI-generated and human-produced videos perform equally well in terms of cognitive processing. However, trust in AI-generated content varied depending on the type. While AI-generated imagery was generally accepted, AI-generated voices were associated with lower trust ratings compared to human voices.

Additionally, significant effects of gender and age were observed for Liking and Retention. Women reported lower liking scores and exhibited lower retention compared to men. Furthermore, age influenced retention, with participants aged 61–70 demonstrating significantly higher retention than those aged 21–30. These findings suggest that individual differences in demographic factors may impact user engagement and information retention, whereas the production method of the videos does not appear to influence cognitive outcomes.

5. Limitations

Our study highlights a significant opportunity for researchers from different backgrounds to engage with the public more actively through social media platforms. Additionally, we find that artificial intelligence/AI-assisted tools can considerably reduce the effort required to create social media videos, thereby lowering the barrier for researchers to participate in digital science communication, even under time constraints. However, despite these promising

findings, several limitations must be acknowledged and addressed in future research.

5.1 Comparability of Video Formats

A key limitation of our study is related to the comparability of different video formats. Due to the constraints on both the preparation and evaluation phases, we limited our sample to eight distinct video styles. Our selection aimed to balance a broad representation of different video genres with an exploration of nuanced variations within specific formats. The videos we created included direct-to-camera presentations, voiceovers accompanied by stock imagery, and a comedic sketch format. Additionally, we introduced subtle variations within some formats, such as the presence or absence of graphical elements in a direct-to-camera video and the use of AI-generated versus real imagery and voiceovers in stock imagery-based videos.

This methodological compromise—between a broad comparative analysis of different video styles and a detailed examination of minor modifications within specific formats—inevitably constrains the scope of our findings. Future research could either expand the range of video formats to encompass a more comprehensive spectrum of social media content or conduct a more fine-grained analysis of specific stylistic elements to understand their distinct contributions to viewer engagement and comprehension.

Furthermore, our study does not account for potential implicit influences and biases that may arise from variables such as the presenter's gender, age, clothing style, or the background setting of the video. Additionally, slight variations in intonation and articulation might still influence the viewer's perception, despite the same script being used between videos. These factors may significantly impact viewer perceptions and engagement. Addressing these biases in future studies, possibly through controlled experiments or meta-analyses, would provide a more comprehensive understanding of the variables influencing social media science communication effectiveness. Additionally, psychological and sociological factors, such as audience predispositions toward certain presenters or their cognitive biases, could play a significant role in shaping viewer reactions and should be explored further.

5.2 Contextual Limitations: Social Media vs. Controlled Setting

Another limitation of our study relates to the controlled environment in which participants viewed the videos. The videos were presented in an isolated, distraction-free setting via a dedicated website, encouraging (though not guaranteeing) full attention from the participants. However, this setup does not accurately reflect the real-world conditions of social media platforms, where users navigate an environment filled with competing stimuli, including comment sections, notifications, algorithm-driven recommendations, and the ability to skip or scroll away from content instantaneously. Given that social media platforms are designed to maximize user engagement rather than information retention, our findings may not fully translate to actual user behavior on these platforms. Future research should explore how different video styles perform in real-world social media environments, possibly through observational studies or A/B testing within platform algorithms.

Additionally, we did not account for the challenge of gaining visibility and reach on social media platforms. Newly created accounts often struggle to gain traction, and building an audience requires significant effort and time. This challenge is particularly relevant to researchers new to social media, as low engagement on initial posts may discourage continued participation. Investigating the impact of algorithmic promotion, follower engagement, and strategies for increasing visibility could provide valuable insights into the long-term feasibility of social media as a tool for scientific outreach. Moreover, future studies could analyze the impact of different social media platform policies, such as video length constraints, algorithmic preference for specific types of content, and community-driven engagement features, on the effectiveness of scientific communication.

5.3 Selection Bias in Survey Participants

Our recruitment strategy for survey participants primarily relied on paid advertisements on Instagram, outreach in student groups, and direct engagement on the streets of Munich. Consequently, our sample predominantly consisted of young, educated, German-speaking individuals, particularly university students. This demographic homogeneity limits the generalizability of our findings, as different age groups, educational backgrounds, and linguistic communities may engage with social media content in dis-

tinct ways. Future research should seek to include a more diverse participant pool, potentially through stratified sampling methods or targeted outreach efforts, to assess the impact of demographic variables on video reception and engagement.

While certain demographic groups may be underrepresented on social media platforms, particularly older age cohorts, their perspectives remain valuable for understanding the broader societal implications of digital science communication. Researchers should consider whether and how specific audience segments might engage with science-related content, even if they are statistically less active on social media. Additionally, future studies should explore whether differences in educational background influence how individuals interpret scientific information presented in videos. For instance, do individuals with more extensive scientific training engage with and trust the videos differently than those with minimal scientific background?

5.4 Topic-Specific Variability

The subject matter of our videos also represents a potential limitation. We selected wind power as the focal topic due to its ongoing political and societal relevance, particularly in Bavaria. However, different scientific topics vary in their public perception, complexity, and level of controversy. Topics that are highly polarizing or require substantial prior knowledge may elicit different audience reactions than those that are more accessible or widely accepted. The extent to which our findings apply to other areas of science communication – such as health, environmental sustainability, or physics – remains uncertain. Future research should examine how the effectiveness of social media videos varies across disciplines and whether certain presentation styles are more effective for specific fields of study.

Further, the chosen topic may have influenced the engagement levels and biases of survey participants. Given the ongoing debates surrounding wind power, individuals with strong pre-existing opinions on renewable energy may have responded differently than those who were more neutral. Future research could assess whether controversial scientific topics elicit greater engagement but also more polarized reactions, while universally accepted topics may be received with less engagement but greater consensus.

5.5 Future Research Directions

Overall, while our study provides valuable insights into the use of AI-assisted video creation for science communication, several limitations suggest potential for further research. Expanding the range of video formats, investigating implicit biases, testing content in real-world social media environments, diversifying participant demographics, and exploring topic-specific effects are all important next steps. Additionally, more advanced methodologies – such as eye-tracking studies to determine which aspects of a video capture viewers' attention – could provide deeper insights into engagement dynamics. Further, longitudinal studies could assess the long-term impact of different video formats on knowledge retention and public attitudes toward scientific topics.

By addressing these limitations, future research can contribute to a more comprehensive understanding of how scientists can effectively leverage social media for public engagement and science communication. Ultimately, ongoing interdisciplinary collaboration between communication scientists, cognitive psychologists, and social media experts could enhance our understanding of how best to bridge the gap between scientific research and public discourse in the digital age.

6. Conclusion

Our project investigated the importance of trust, comprehension, liking, and retention in science communication on social media platforms. While AI-generated videos offer considerable advantages in terms of production efficiency, the results indicate that human elements – such as a visible speaker and natural voice – significantly enhance perceived trustworthiness. Although AI can produce structured and factually accurate content, audiences express greater trust in human-generated material.

Notably, most video formats did not lead to substantial differences in audience responses regarding comprehension, liking, or retention. However, trust ratings were influenced by video format, with the interactive self-interview receiving the highest levels of trust. Additionally, content featuring AI-generated voices consistently received lower trust ratings. This finding highlights the value of human presence and suggests that authenticity, as conveyed through natural speech, remains difficult for AI to replicate. At the same time,

comprehension and retention scores did not differ significantly between AI- and human-generated content, indicating that AI can support effective science communication when applied thoughtfully.

In addition to content format, demographic factors influenced participants' responses. Older individuals demonstrated higher retention, potentially due to increased focus or prior familiarity with the video topic. Gender differences also emerged, with women reporting lower levels of enjoyment. These findings underscore the importance of accounting for audience diversity in the design of science communication materials and highlight the need for inclusive approaches that resonate across demographic groups.

The study also draws attention to the challenges posed by misinformation in digital environments. By embedding deliberate inaccuracies into the videos, we assessed viewers' ability to detect false information. While some participants were able to identify misleading claims, many struggled to do so—reinforcing the need for improved media literacy and transparent, well-sourced communication.

To build on these findings, future research should examine how different formats perform in real-world social media environments. Metrics such as viewing duration, sharing behavior, and user interaction could provide a more comprehensive picture of audience engagement. Moreover, investigating long-term retention could offer insight into the sustained impact of short-form science content. The role of AI in expanding accessibility also presents a promising area for further exploration. Features such as automated translation or personalized content delivery may enhance inclusivity.

In conclusion, our project provides valuable insights into using social media for effective science communication. While AI-generated content offers significant advantages in terms of efficiency and scalability, human contribution remains essential in building trust and engagement. Science communicators must balance AI efficiency and human authenticity to ensure their content is accessible and trusted. By continuing to refine these strategies, researchers and communicators can bridge the gap between scientific knowledge and public understanding, fostering a more informed and scientifically literate society.

Literature

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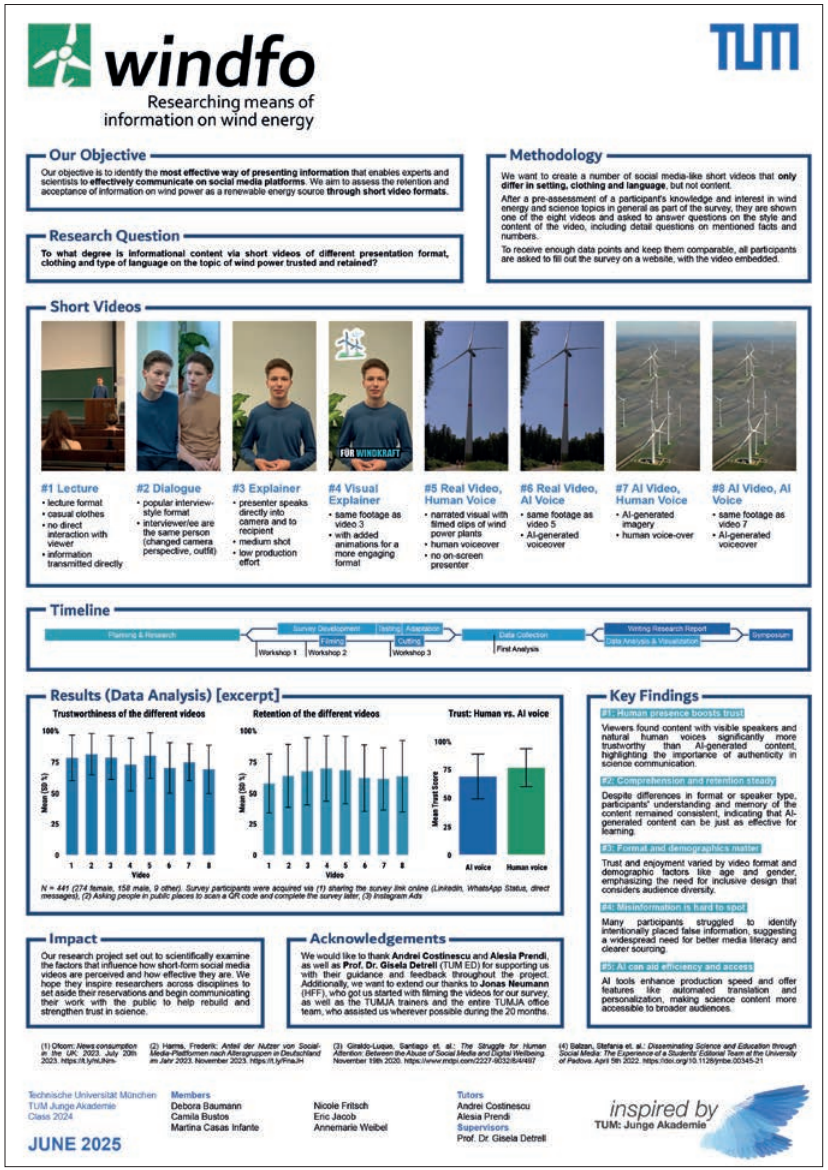
Process description



After approximately 4 months of discovery phase, which started off with ideas for improving mental health among hospital patients, continued with brainstorming ideas for tools for effective use of renewable energies, we finally found our topic in science communication. Wanting to retain the aspect of renewable energy, we focused specifically on wind energy.

As we explored science communication, we noticed a lack of researchers sharing their knowledge on social media. Given the prevalence of misinformation and the risk of uninformed decision-making, we recognized the need to identify effective ways of communicating scientific content on these platforms.

For this, we decided to create our own short videos. First, we had to define the variables for our analysis. To keep certain factors constant, we chose Eric as the presenter for all videos requiring a visible person, and we used the same script across formats. We produced a range of video formats, including more engaging styles and others featuring AI-generated imagery or voiceovers.

Afterwards, the social aspect of our research followed: recruiting enough participants for our survey proved challenging. By walking around Munich, reaching out to friends and family, and experimenting with Instagram ads, we ultimately gathered sufficient responses. Our survey assessed each video's attentional impact, perceived trustworthiness, and audience retention. The results show that engaging videos appeal to people, and AI-generated content does not necessarily decrease the quality of the video.

The results reinforce our appeal to scientists: be bold in sharing on social media. We are excited about our findings and plan to create a short guideline for scientists on producing effective videos for social media.


windfo
TUM
PIXIDA

Self-Reflection windfo

How do you carry a project through 20 months of research when your topic changes along the way? That's one of the core questions we've had to face on our journey as team windfo – a team that, in the end, learned to embrace change rather than fear it.

At the beginning of our TUMJA journey, our goal was to explore how the quality of life for patients in retirement homes and hospitals could be improved. It was a topic close to our hearts and seemingly rich in possibilities. But as we dove deeper into the literature, it became increasingly clear that our original question had already been studied quite thoroughly. It was a tough realization, especially after investing time and energy into a direction that suddenly didn't feel meaningful anymore. But in hindsight, it became one of our most valuable lessons: research is not a linear process, and flexibility is essential. Changing our topic mid-way was not a failure – it was the start of truly learning how to do research.

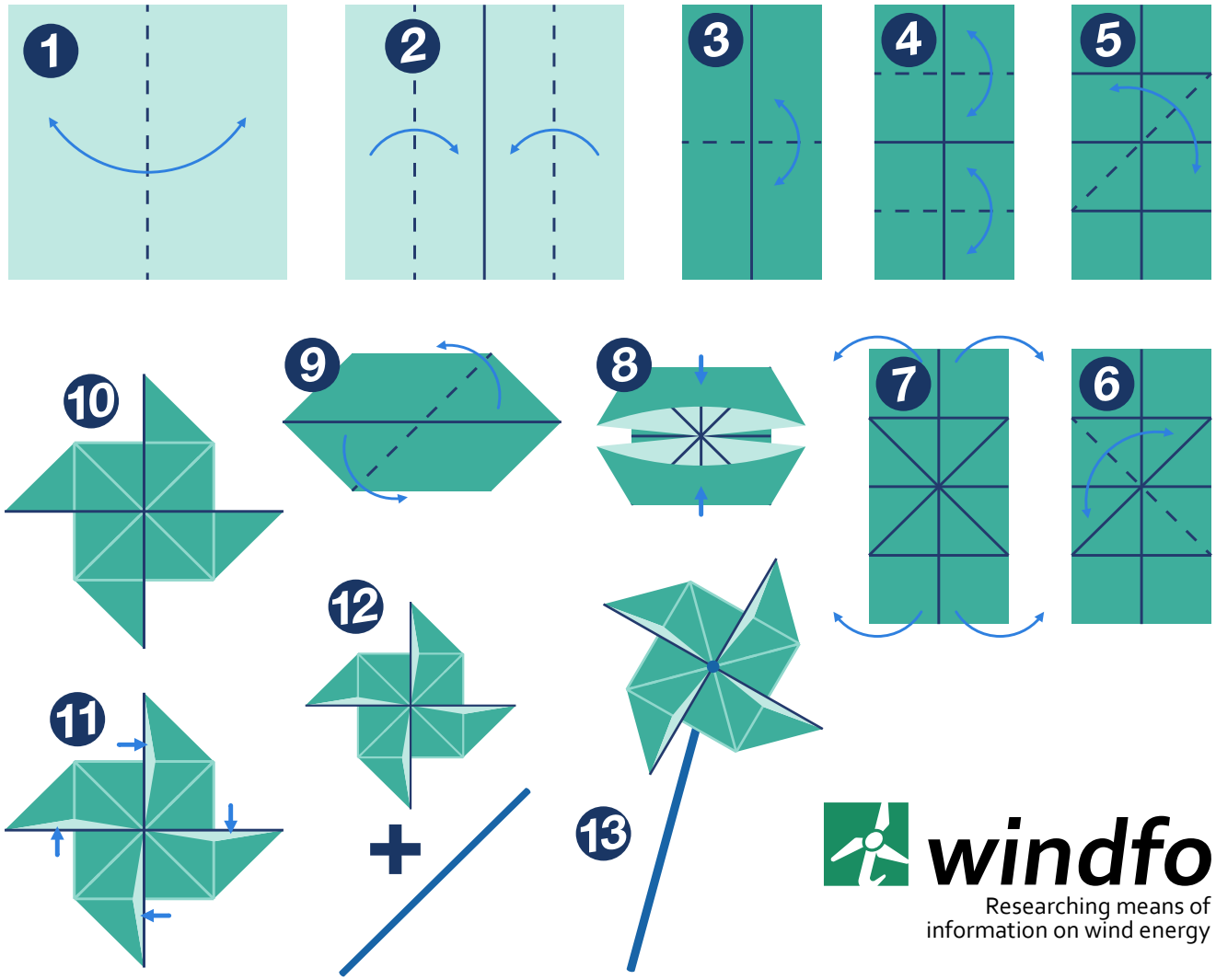
With a new focus came new motivation, but also new challenges. One challenge that consistently reappeared was teamwork. Collaborating in a team sounds easy on paper, but we quickly found ourselves navigating different working styles, preferences, and expectations. At times, balancing everyone's interests required compromise and, occasionally, uncomfortable conversations. Still, this process taught us how to accept and appreciate each other's quirks and differences. Learning to work together despite our contrasts made our team more resilient – and more human.

Another lesson we learned early on: a self-organized research project won't move forward unless someone makes the first move. Taking initiative was key. Without structure or deadlines from outside, we had to become our own project managers. It was both liberating and demanding, and we're proud that we managed to keep the momentum going – even if we stumbled along the way.

One area where we, in retrospect, see room for improvement is communication – especially with our supervisors and tutors. While they were always available to support us, we didn't always make enough use of that support. More proactive communication from our side could have helped us get through some of the rougher patches more smoothly. It's a lesson we'll carry forward: don't hesitate to ask, to check in, to stay in touch.

Looking back, we see a team that didn't have all the answers but was willing to ask the right questions. We shifted course, learned to self-organize, found balance in our differences, and understood that research is rarely a straight path. Our journey as windfo was not just about the final results – it was about becoming better researchers, better team players, and more reflective individuals. ■

Make your own Pinwheel



Highlights 2024

A year full of ideas, encounters, and impact: Looking back at #class24

With #class24, the TUMJA office team once again experienced what makes our academy special: young talents who research with passion, think across disciplines and grow together. Under the guiding theme “What makes us human?” bold projects emerged, opening new perspectives and offering valuable insights into pressing societal questions.

This success was made possible by a strong network of fellows, tutors, supervisors, and alumni, characterized by trust, openness, and genuine collaboration.

We say goodbye to a remarkable group that leaves lasting traces within the academy, the university, and far beyond. Thank you for this journey full of curiosity, humanity, and connection across the globe. ■

2023

The journey of #class24 began at the **Kick Off Weekend** in Wartaweil in November 2023

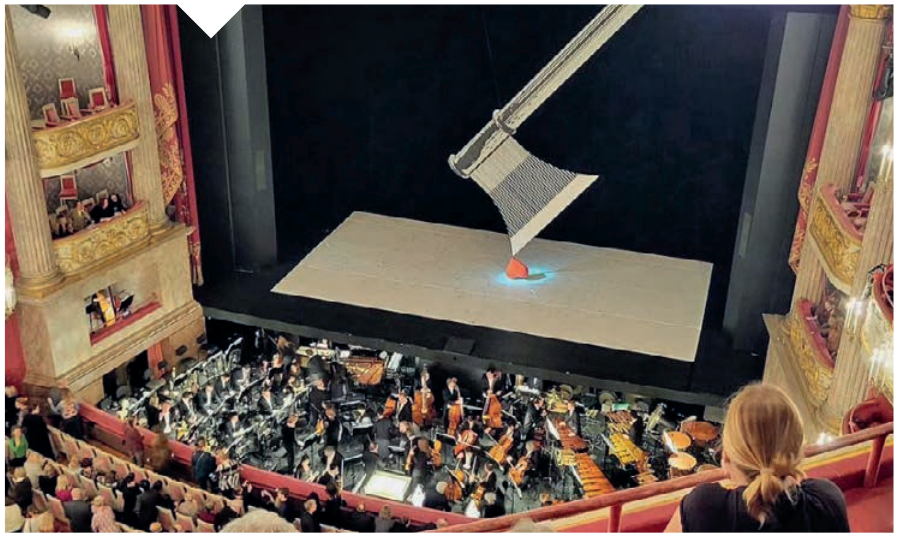
Seminar 1a in December 2023

Future Lab in Possenhofen in January 2024

Wordshops Prosathek in Febuary 2024

November | December | January | Februar

TUMJA goes Culture: Alice in Wonderland in March 2024



Intermediate Evaluation 1 + 4
in April 2024

BoM-Meeting in April 2024

Campus Run in Garching
in May 2024

Fireside Chat in May 2024

2024

March | April | May | June

2024

Symposium "Less is more" of #class23 in June 2024

Street Science on ZAMANAND festival

Dragonboat Race in June 2024

June | July

Information Event for #class25
in August 2024

TUMJA Summer Party in Garching in July 2024

InsEYEght workshop in August 2024

August | September

2024

2024

Intermediate Evaluation 2 of #class24
in September 2024

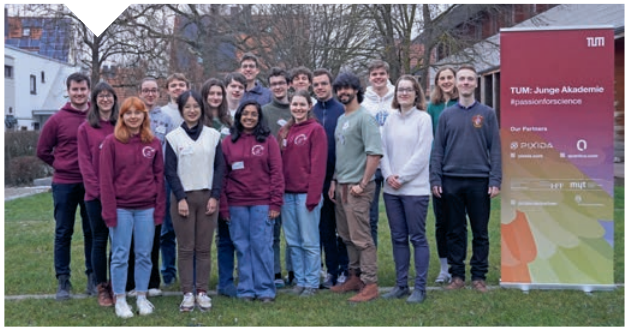
Trip to Berchtesgaden in October 2024

Selection Days #class25 in October 2024

September | Oktober | November | December

Intermediate Evaluation 3
in Wartaweil in November 2024

Future Lab 1 + 2 in January 2025



TUMJA meets TUM Ambassadors
in December 2024

Wordshops Reading + Kick Off
in Febuary 2025

January | February

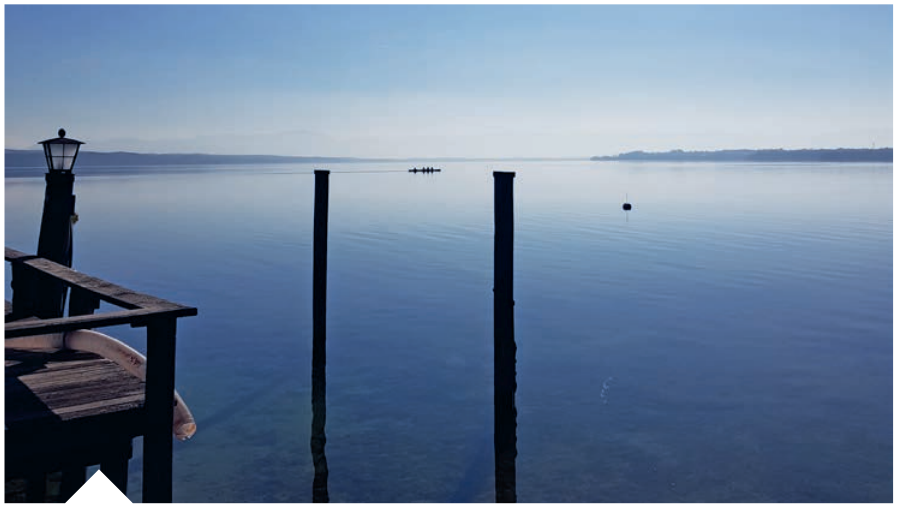
2025

2025

Intermediate Evaluation 1 + 4
at Burg Schwaneck in April 2025

Campus Run in Garching in May 2025

Symposium "What makes us human?"
of #class24 in June 2025



The journey of #class24 ends with the **PAWE** in July 2025

April | May | June | July

Wordshops

An ending and a new beginning
In the second round of Wordshops, thirteen writing enthusiasts have been letting their literary short stories blossom under the motto “Stilblüten.” Our floral contribution to the Munich Flower Power Festival came as an anthology packed with murder, love, sadness, flowers, and literally everything else you can imagine. A big thank you goes out to the “Prosathek” – a Munich-based authors’ collective, which helped us with proofreading, editing, and valuable insights from an author’s life. The final highlight of the writing workshop was the joint reading by the authors from the newly published anthology in January 2025.

The conclusion of Wordshop II was also a new beginning, namely the kick-off for our third round of Wordshops. The exciting motto, under which writing enthusiasts from TUM have once again come together, is “Langeweile.” Over the weeks, the participants started to dive into inspiring workshops, engage in thought-provoking discussions, and work towards publishing their pieces. We’re excited to see where their words will take them!

If you want to join our growing writing community, drop us a few lines.

wordshops@ja.tum.de

TUMJA SLAM

What is TUMJA SLAM?
TUMJA SLAM is a bi-weekly event where participants gather to discuss topics of interest, ranging from the scientific to the purely entertaining. The format is simple and engaging: each session features one or two presentations, followed by a relaxed socializing session. The primary goal is to foster connections across teams, encourage learning, and experiment with different presentation styles.

The Present
In the last year, TUMJA SLAM again covered a wide array of topics such as “Placebo Effect,” “Seeing is Believing,” “Political Extremism,” “Are there aliens in the Solar System? NASA’s Europa Clipper Mission,” “A Short History of Democracy or Why You Should Care About Politics,” or “Asexuality and what we can learn from it.” Thus, TUMJA Slam further established itself as an informal, fun, and intellectually stimulating environment where participants feel comfortable sharing their passions and curiosities.

The Future
Looking ahead, TUMJA SLAM aims to continue its tradition of fun and intellectual curiosity. We are excited to welcome new presenters and audience members alike.

Yours truly,
TUMJA SLAM

TUM Campus Run 2025

The TUM Campus Run 2025 took place on May 14, starting at 5:00 p.m., and attracted nearly 2,500 enthusiastic runners. This year's "Bad Taste" motto, with a wide variety of colorful and creative outfits, brought smiles to participants and spectators.

The race offered a varied mix of scenery, leading runners around the university campus and into the adjacent forest and meadows. The *MiaSanTUM Cheerleaders* lined the route and the finishing stretch, offering motivation and encouragement throughout the event. Musical support came from *Bateria Z – LatinPowerDrums* and the *Praias do Isar Samba School*. Fresh fruit and refreshing drinks were served at the finishing area of the running event to replenish energy levels.

In the 5.5 km race, the fastest male runner was Jan Böttcher, finishing in 18:42 minutes, while the fastest female runner was Julia Rath with a time of 20:26 minutes, followed by TUMJA alumna Pia Gutsmiedl, who came in second, finishing with 21:51 minutes. In the 11 km distance, Pavol Brejcák claimed the top spot among the men with a time of 34:43 minutes, and Anna Kuntscher was the fastest woman, completing the run in 42:14 minutes. In the professors' challenges, Laura Fabietti and Filip Mess again won the first prizes. The fastest chair over 11 km was EES Rapid 1, while team ZHS Triathlon 1 won the Team Challenge over 5.5 km. The TUMlinge-Challenge over 11 km was topped by Rolands Rasende Rabauken 1.

After the run, participants gathered at the campus pub C2 in Garching for the After-Run Event, where they celebrated their achievements and enjoyed a relaxed evening together.

A heartfelt thank you goes out to all the organizers and volunteers whose dedication and hard work made this year's TUM Campus Run such a successful and memorable event. ■

TUMJA Symposium 2025 on “What makes us human?”

After 20 months of intense work, the scholarship holders of #class24 presented their projects and findings at an inspiring and entertaining evening.

The Taskforce Symposium had put together a varied program. After a welcome address by TUMJA’s Director, TUM Senior Vice President Professor Gerhard Müller, the five teams of #class24 outlined their projects in short presentations. Bushra Demyati and Omar Rashed, members of #class24, led the program as moderators.

The evening continued in the Theresianum with a conference. The guests could listen to and discuss diverse scientific topics in three lecture halls under the joint motto “What makes us human?” The twelve talks ranged from technical themes like autonomous vehicle systems to biological issues, such as “synthetic biology,” and touched on philosophical and psychological aspects. Lively discussions with the audience followed the short talks.

After this insightful part of the evening, everybody was invited to enjoy some refreshing food and drinks for a “walking dinner.” The projects of #class24 and #class25, as well as TUMJA partners and different student initiatives, invited the guests to explore their interactive booths. This engaging session could have lasted even longer, but the final event of the evening was calling: A science comedy show with “Magic Andy.”

Our heartfelt thank you goes to the organizing team under the lead of Taskforce Symposium, whose outstanding commitment made this inspiring, cheerful evening possible. ■


WELCOME TO
THE
SYMPOSIUM OF
#CLASS24

Cooperations

Cooperations

Partner Universities

TUM: Junge Akademie is an initiative of the Technical University of Munich. In order to increase the interdisciplinary exchange beyond the manifold disciplines of TUM, additional universities from Munich have been invited to join the network since 2016.

“Since 2017, the presidents of the partner universities HFF and HMTM have been members of the TUMJA Advisory Board. In spring 2023, the new president of the Academy of Fine Arts, Professor Karen Pontoppidan, joined the board, thus strengthening the partnership of the academic foursome. A warm welcome, and here's to a successful and continuous further development of the heterogeneous and fantastic journey between the disciplines within the university environment in Munich!”

Peter Finger
Managing Director, TUMJA

AKADEMIE DER
BILDENDEN KÜNSTE
MÜNCHEN

Academy of Fine Arts Munich (AdBK)

The Academy of Fine Arts Munich is one of the three artistic partner universities of the TUM: Junge Akademie and joined the network in 2019. Approximately 800 students are currently enrolled at the Academy of Fine Arts in Munich. Each student is assigned to a class of his/her choice, selected during the admission process. The Academy of Fine Arts Munich considers itself as an experimental laboratory and includes a total of 25 classes. Training at the academy focuses primarily on the development and practice of artistic skills and abilities in the fine arts. It also offers advanced degree programs in “visual design and therapy”, “art and architecture”, “interior architecture” and “art and communication”. The talents of students are developed according to their major field of study and their personal interests. Curricula and teaching principles are based on self-reliance and personal responsibility.

University for Television and Film Munich (HFF)

Compared to the TUM, the "University of Television and Film Munich" (HFF) is a tiny school with around 350 enrolled students. However, the HFF is one of the oldest film schools in the world, founded in 1966, and is very successful as one of the premier film schools worldwide. The HFF Munich offers eight different degree programs: from directing to camera to script-writing. Emphasis is put on collaborating and storytelling through the medium of film with the help of world-class professors and teachers such as Prof. Julia von Heinz ("Und morgen die ganze Welt") or Maria Schrader (Emmy for "Unorthodox"). The school's illustrious alumni include Caroline Link, Doris Dörrie, Bernd Eichinger, Florian Henckel von Donnersmarck, Wim Wenders and Roland Emmerich. In 2011, the school moved to its newly purpose-built facility in the heart of the Munich art district. It continues to explore the medium of film and pushes the boundaries of the moving image, for example by creating a new VFX study program or researching AI and its possibilities for film.

University of Music and Performing Arts Munich (HMTM)

The Munich University of Music and Performing Arts is one of the largest universities in the cultural sector in Germany. It was founded in 1846 as the Royal Conservatory of Music and has borne its present name since 1998. The university offers more than one hundred different study programs in all fields of music, dance, and theatre, culture management, or journalism. More than 1.200 students from all over the world study at HMTM. The study programs prepare for artistic, pedagogical and scientific professions. In many fields of arts, tradition plays a very important role. The HMTM wants to keep the strengths of this tradition at the university. At the same time, new areas are developed like digitalization, digital art forms and questions of artistic research. Art develops best in an environment of free-thinking, experimentation, and creativity. Our university intends to be a creative laboratory for the students, professors and researchers, as well for the society.

Creating Sustainable Networks – EuroTeQ Collider at TUM: Junge Akademie

Modernizing engineering education within the European Union while creating and strengthening connections with each other and our environment – that is the aim of the EuroTeQ Collider.

Located at TUM: Junge Akademie (TUMJA), the Collider ties into the challenge-based learning focus that the Junge Akademie (TUMJA) pilots and refines within the TUM ecosystem. Similar to the projects that the TUMJA scholarship holders work on, the student teams in the EU-funded Collider develop solutions to concrete problems under the guidance of experienced professionals.

Given the similarity of the learning approach, the Collider benefits from TUMJA's rich network of alumni, active professors, and the TUM Emeriti of Excellence, as well as young researchers. For instance, TUMJA alumni joined the Collider as trainers on agile project management and design thinking, and gave the Collider participants valuable insights into these topics.

The Collider expands TUMJA's exceptionally vibrant network by the EuroTeQ Alliance Universities, which consists of nine leading European technical universities and business schools working together to shape the engineering education of the future. The Collider is one of the centerpieces of this international initiative.

More than 70 motivated students participated in the fifth Collider at TUM, where they tackled highly diverse challenges ranging from increasing biodiverse green spaces in service centers to issues of cultural relevance, such as the development of culturally sensitive robots in the tourism sector.

The three teams whose solutions convinced the jury competed against the project groups from the other EuroTeQ partner universities at the EuroTeQaThon in Eindhoven in June. 'Mobility for Offliners' is reducing barriers to mobility for seniors in Eching in the north of Munich, while 'BRIQ' partnered with Tukule foundation, an NGO in Uganda, to increase efficiency and reduce pollution in the carboniser used by the local communities. The third team, 'BioThermoBox', developed a transport solution to keep produce fresh throughout transport in humid climates in Uganda. BRIQ convinced the international jury in Eindhoven and came in second place in their category, while BioThermoBox got first in theirs.

On top of the three strong teams who travelled to Eindhoven, the EuroTeQ Alliance supports one especially promising team that wants to take their project further than the Collider with an entrepreneurial bootcamp organized by our partner university, IESE Business School in Barcelona, at the end of July. This year, Envirolink, which is connecting the efforts of small and medium enterprises to reach the 17 UN SDGs, will have this opportunity.

The achievements of the Collider teams show how TUMJA not only nurtures the academic growth of its students but also equips them with the skills to tackle pressing real-world challenges. Thereby, the EuroTeQ Collider instances TUMJA's commitment to modernizing education within the European Union and beyond. ■


EuroTeQaThon 2025
Final Pitch presentations

Industrial Partner – QuantCo

QuantCo leverages its data science, engineering, and business expertise to help companies turn data into decisions. The company is headquartered in Boston and has offices in Munich, Berlin, Hamburg, Cologne, and Karlsruhe.

The team of over two hundred data scientists, software engineers, and machine-learning experts creates tangible business impact by combining cutting-edge data expertise with business acumen. Its product suite includes algorithmic pricing, data-driven claims management, and high-dimensional forecasting solutions. Customers include some of the largest financial, retail, industrial, and healthcare companies in Europe and the US.

We are excited to continue our partnership with TUM: Junge Akademie into our third year! We joined the TUMJA students during a weekend at Dachau and introduced them to the art of analyzing and visualizing data. The workshop, presented by an alum of TUMJA, highlighted the importance of conveying technical information to a non-technical audience. This skill is relevant to the participants' projects, which we also put into practice using their research results.

We started our partnership with TUMJA in the academic year 2022/2023 thanks to several TUMJA alums who joined QuantCo. Since then, we have organized several events and look forward to the ones still ahead! ■

TUMJA Alumnus Marius Merkle from QuantCo at the Visualization Workshop in January 2025.

Industrial Partner – Pixida Group

Since 2016, PIXIDA GmbH has proudly partnered with TUM: Junge Akademie. Our experts in digitalization, IoT, and mobility regularly exchange knowledge with highly motivated students to jointly explore innovative solutions for urban and societal challenges.

Over the years, this partnership has grown steadily. PIXIDA contributes through in-house workshops, mentoring, and active participation in events such as the annual Science Hack.

At the 2019 Science Hack, two student teams developed web apps to promote eco-friendly driving. Both visualized trip eco-scores with features like live maps, sharing options, detailed trip data, and personalized recommendations.

In 2021, the hackathon theme "The New Normal – Sustainable & Inclusive Cities after the Pandemic" led to the development of web apps visualizing public transport occupancy. Based on WiFi probe requests, the solutions estimated occupancy in real time and highlighted the business potential of PI Labs FleetKey solution.

Beyond hackathons, PIXIDA also actively engages in other collaborative formats. We have supported TUM: Junge Akademie's scholarship selection process, mentored student teams during kickoff workshops, and hosted internal feedback sessions on ongoing projects.

From 2020 to 2021, PIXIDA supported two project teams with dedicated mentors: TUMwelt developed an app to promote sustainable urban mobility among young adults, while AppCycle focused on mapping recycling and upcycling spots in Munich. PIXIDA provided guidance in areas such as architecture, data security, and UX design.

In 2022, PIXIDA organized a coaching session for Class 22 teams. The students pitched their ideas to experienced PIXIDA colleagues and gained valuable insights in terms of risk identification and optimization.

At the 2023 Science Hack on "Trustworthy Systems," PIXIDA challenged students to include customer trust in a usage-based insurance concept. The result: a live crash detection feature paired with initiative-taking, personalized support — a solution that secured our team the 2nd place.

In the context of the EuroTeQ Collider 2024, students developed a concept for a platform facilitating collaboration in global teams. The tool introduced an innovative approach: planning meetings through personas rather than individual calendars.

Also in 2024, our collaboration continued with a PIXIDA in-house event where teams from Class 24 and Class 25 presented their current project ideas to receive feedback and input from our experts. Furthermore, a "Food for Thought" session on the topic of Artificial Intelligence provided an engaging platform for exchange between students and professionals on the impact and potential of AI in society.

As part of the TUM Selection Days, an assessment format to identify the future scholarship holders of class 25, PIXIDA colleagues contributed as interviewers. We thank all students for their passion, creativity, and social commitment.

Let's continue this inspiring and constructive cooperation in the years ahead! ■


ENGINEER


COLLIDER


PIXIDA
Connect with Pixida !
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Taskforces

Taskforces

Taskforces

Taskforce CAP

Contacts, Alliances, Partnerships – We, as CAP, are the taskforce responsible for cooperations between TUMJA and external partners. We aim to establish a lively network between current scholarship holders and alumni, industry partners, and academic institutions.

TUMJA benefits from strong partnerships with companies. Our partners not only supplement our budget but also offer enriching and insightful seminars to all scholarship holders. For example, Pixida hosted an exclusive in-house event where all teams could present their research project and get direct feedback from Pixida's industry experts. We are proud to continue our long-lasting partnerships with Pixida and QuantCo, and we look forward to yet another exciting year with them by our side.

As a taskforce, we spent most of our time organizing the Science Hack 2025. The Science Hack focused on the plethora of challenges we, as a society, will face in the following decades. These challenges will ask a lot of us and force us to leave paths to which we have become accustomed. This is why the Science Hack theme was: Going New Ways. The hackathon was held on the weekend from 20 to 22 June. Partners from both industry and academia posed challenges addressing the theme. We were especially excited about collaborating with TUM Venture Labs – a partnership we can hopefully extend in the coming years. Student teams from all disciplines worked on these challenges and developed novel approaches for solving them. We were delighted to host this event and work hand in hand with the new members of CAP from #class2025.

As a taskforce, we thoroughly enjoyed working with our partners and supporting the mission of TUMJA. We learned a lot during our time in the taskforce and are grateful for the opportunity. We wish all the best for the endeavors of #class2025 and the next taskforce CAP!

Class 2024
Joshua Fehn
Samuel C. Friese
Tim Knothe
Julius Mankau
Nikola Martinov Staykov
Oliver Meixner
Christian Nix

Class 2025
Gentian Gallgjini
Pia Mütsch
Mario Rodriguez Vercantes
Sebastian A. Strobl
Niklas Vart
Jasper Veil

Taskforce Senior
Philipp Patzelt


Leitbild
PYXIS
TRUST

Taskforce Event

Who are we?
We are the Taskforce Event of TUMJA, a team of motivated scholarship holders who come together to create meaningful experiences for the TUMJA community. With diverse backgrounds and perspectives, we aim to foster connection, creativity, and a sense of belonging through shared activities and events.

What do we do?
We organize a wide range of events throughout the year — from the Frühlingsfest get-together in spring to BBQ parties and a Dragonboat Race in summer, from Fall Party in autumn to Weihnachtsmarkt visits in winter. Some events are long-standing traditions, such as the Dragonboat Race, while others reflect new ideas brought in by members. Everyone in the team can contribute and shape the event calendar with their own creativity.

What is our connection with TUMJA?
As part of TUMJA, we represent the network of scholarship holders at various university and public-facing events like the TUM Student Club Fair or IKOM. We actively build bridges between current scholarship holders, alumni, mentors, and supervisors, thereby strengthening the TUMJA spirit within and beyond the academic setting.

Our Motivation
We believe that building a vibrant and inclusive community beyond academic excellence is essential. Through shared events — whether it's cheering at a Dragonboat Race or singing together at our Christmas Karaoke Night — we create moments that connect people, spark inspiration, and form lasting memories.

Highlights
Spring awakens with blooming delight,
At the Frühlingsfest, spirits take flight.
We raise our mugs to Bavarian cheer,
Welcoming warmth and the start of the year.

Summer brings sunshine, golden and bright,
With BBQ parties well into the night.
Laughter and joy in every bite,
And on the lake, we row with pride —
Paddles slicing water, sweat and drive,
At the Dragonboat Race, we come alive.

In Autumn, the air turns crisp and sweet,
At the Fall Party, where old friends meet.
Pumpkin soup and baguette in hand,
We celebrate the season across the land.

Then comes Winter, with glowing light,
The Christmas Market warms the night.
Glühwein steaming, gingerbread delight,
A cozy escape in the festive twilight.
And at our Christmas Party, voices rise,
With karaoke songs and Just Dance highs.
Laughter echoing, hearts open wide,
In every season, we stand side by side.

Class 2024
Verena Aures
Maximilian J. Frank
Maximilian Hillgärtner
Praissya Nathania
Max Schultz
Yunqing Wang

Class 2025
Janna M. Behrens
Anna Brackhagen
Emre Ilhan
Niklas Hellriegel
Niya Lafazanska

Taskforce Marketing

Collaboratively presenting TUMJA
We, Taskforce Marketing, play a key role in shaping how TUMJA is perceived, both within TUM and beyond. Our goal is to make TUMJA more recognisable and relatable by communicating its mission, projects, and initiatives in engaging and accessible ways. Through collaboration with other taskforces and independent campaigns, we work to increase the visibility of TUMJA with creativity, energy, and a strategic focus.

Creating a visual identity for #class25
As a team, we took time to reflect on and interpret the call of #class25 – *Future Societies: new options, new competencies, new dynamics* – to ensure our designs aligned with its message. We aimed to capture the core themes and spirit of the call in every element we created. We designed the application flyer distributed to students as part of their invitation. Building on this design, we also developed posters which were displayed at key events such as IKOM and the TUM Open Days, as well as at the TUM Main Campus and our partner universities. Our goal was to make these materials visually striking while clearly and concisely communicating the mission and goals of TUMJA.

In keeping with tradition, Taskforce Marketing designed the hoodies for #class25; this year in an aquamarine colour to represent the call. In addition, we introduced new merchandise items, including socks and sweaters featuring the TUMJA graphic.

More engagement on social media
We embraced new challenges by expanding our presence on social media. Our goal was to make our Instagram page more informative and appealing, providing a clear overview of who we are and what we do, even to those unfamiliar with TUMJA. To achieve this, we developed Instagram highlights showcasing: the research groups and their topics; the various taskforces and their roles; and events in which TUMJA is involved – such as the TUM Campuslauf, the Science Hack, and the EuroTech Collider.

Incorporating successes from the past
As a taskforce, we enjoyed a great deal of freedom in developing and implementing both ongoing and new projects. We had the flexibility to choose what we got involved in and how deeply engaged we became. This enabled us to pursue initiatives aligned with our interests: whether it's exploring new formats for the research report by hosting a workshop during one of the seminar weekends with the other scholarship holders, or reviving the long-lost TUM Muesli created by team "EatMe. I'm fancy!" from #class17. New members were encouraged to take ownership of their ideas and lead their own projects from the start.

Learning by doing
Most of our members joined without prior experience in marketing or design. However, this was never a limitation. We are a team of curious, motivated individuals who are eager to learn, experiment, and support each other. Together, we generated fresh ideas and found creative ways to achieve our goals. Being a part of Taskforce Marketing gave us the space to build design skills, explore marketing strategies, and contribute meaningfully to how TUMJA presents itself to the world. Our members are committed to making the academy's work visible and impactful.

Class 2024
Bushra Demyati
Elke Haldmaier
Lucia Arens
Martina Casas Infante
Nicole Fritsch

Class 2025
Ugne Bagdonaite
Gabriel Battel
Clara Farr
Martin Lledo Gomez
Franka Spitczok von Brisinski ■


TUM: Junge Akademie
Passion for Science


This year's call:
Future societies
new options
new competencies
new dynamics
TUM: Junge Akademie
Passion for science


Welcome #class2025


Future societies

Taskforce Mentoring

The Mentoring Program at TUMJA
Taskforce Mentoring has been dedicated to organizing a meaningful mentoring program for its scholars. We believe mentoring is an enriching experience, offering immense benefits to mentors and mentees. It is an important part of personal and professional development within the curriculum of TUMJA. Through our program, we facilitate one-on-one connections between current scholars and alumni of TUMJA, enabling the transfer of advice and inspiration from alumni to the next generation. Simultaneously, mentors remain actively connected with their alma mater and gain fresh perspectives from enthusiastic young scholars.

Achievements of the Mentoring Program
We are proud to reflect on a milestone achieved this year: the transition of our carefully planned program into reality. Again, many alumni of TUMJA joined as mentors, while scholars from the class of 2024 enthusiastically embraced the opportunity to participate. Our scholars signed up and were presented with a curated list of potential mentors, complete with their academic backgrounds, LinkedIn or XING profiles, and other relevant details. Allowing mentees to select their mentors proved to be a key feature of the program, as it empowered them to prioritize individuals they felt most aligned with. A matching tool then finalized the pairings.

In June 2024, we hosted a kick-off event at a traditional Bavarian Biergarten. This gathering introduced the mentor-mentee tandems, clarified the program structure, and, most importantly, fostered a sense of camaraderie during an enjoyable evening together.

The program's flexibility allows each tandem to tailor their interactions to suit their needs. While a minimum of four meetings over the course of a year is encouraged, the frequency, location, and topics discussed are entirely up to the participants. Discussions can range from academic challenges to personal growth. A closing event will celebrate the end of the program and serve as a launchpad for the next year of mentoring tandems.

Expanding Horizons with TUM Ambassadors
In recent years, we have also introduced an exciting new dimension to our mentoring initiatives: collaborations with TUM Ambassadors. This exclusive opportunity offers scholars the chance to engage with a select group of internationally renowned researchers, who are honored annually for their significant contributions to TUM's research landscape.

This year, the distinguished TUM Ambassadors include:
- Noelle Selin (Massachusetts Institute of Technology, USA)
- Ron Heeren (University of Maastricht, The Netherlands)
- Gustavo Goldman (University of São Paulo, Brazil)
- Shobhana Narasimhan (Jawaharlal Nehru Centre for Advanced Scientific Research, India)
- Henrik Selin (Boston University, USA)
- Iris Tommelein (University of California, Berkeley, USA)

Beyond their remarkable scientific achievements, these individuals share relatable beginnings as students. Through this initiative, a select group of TUMJA scholars has the unique opportunity to engage in in-depth discussions with the Ambassadors. Topics include career planning, overcoming challenges such as writer's block during thesis work, and navigating life-changing decisions. These interactions could evolve into long-term mentorships, although participation remains optional.

Looking Ahead
As we reflect on the journey of the mentoring program, we are immensely proud of its growth and impact. The foundation we have built sets the stage for an even more dynamic future. We eagerly anticipate the evolution of our mentoring tandems and the rich insights to be gained from our collaborations with TUM Ambassadors.

The path forward is bright, and we are committed to continuing this rewarding journey. Stay tuned for more updates and opportunities to get involved!

Class 2024
Annemarie Weibel
Chiara Deleu
Corinna Mack
Omar Rashed
Viktoria Obermeier

Taskforce Senior
Robin Weiß

Class 2025
Rico Finkbeiner
Elia Ruthner
Vidushi Saxena
Abdullah Saydemir
Rupert Zeps

Taskforce Recruiting

Overview 2024
As members of Taskforce Recruiting, we take care of guiding new potential members through the application process. This begins with nominations and ends with the final selection of scholarship holders shortly before their kick-off. Our goal is to select highly motivated students who are willing to contribute to TUMJA in a great measure.

To be able to recruit new scholarship holders for TUMJA on a yearly basis, our work begins with the nomination of talented students. Therefore, we are in close contact with the individual departments to identify the best 7 to 25 percent of all students, who are in turn nominated by us and Professor Müller.

The application process additionally involves planning and organizing information events for interested students, where we give everyone the opportunity to meet active members and gain first-hand insights into TUMJA. In the summer of 2025 we, in collaboration with Taskforce Marketing which was responsible for advertising, hosted three information events with a total attendance of approximately 300 students.

During the application phase we are responsible for evaluating the incoming applications of potential scholarship holders based on predefined criteria. Here, the applicants' personal motivation, ideas regarding the call, and genuine interest in TUMJA are the most important factors.

Finally, we are responsible for organizing the selection days. During these two days, the applicants are asked to participate in various individual or group tasks, such as presenting their proposed project ideas described in the essays, or having an interview with other scholarship holders, tutors, or supervisors. Accordingly, based on this performance, about 40 to 50 students are chosen to join TUMJA.

We always aim to ensure an objective and unbiased evaluation of the applicants. Therefore, every year we tackle questions such as: What can be improved in the application process? How can the application process be made as transparent and fair as possible? How can applicants be evaluated and compared in the best possible way?

In the past two years, we have made significant changes to the recruiting process. We anonymized the application documents including the letter of motivation, the CV and the essay/video, which ensures that we can rule out unconscious influences on our decision-making. We re-evaluated the scoring and admission criteria for both online application and the selection days and developed a new method for finding the nomination percentages, which could theoretically even be applied to study programs. By coming up with the new, more insightful and engaging group activities and re-evaluating the interview questions we completely restructured and reorganized the selection days.

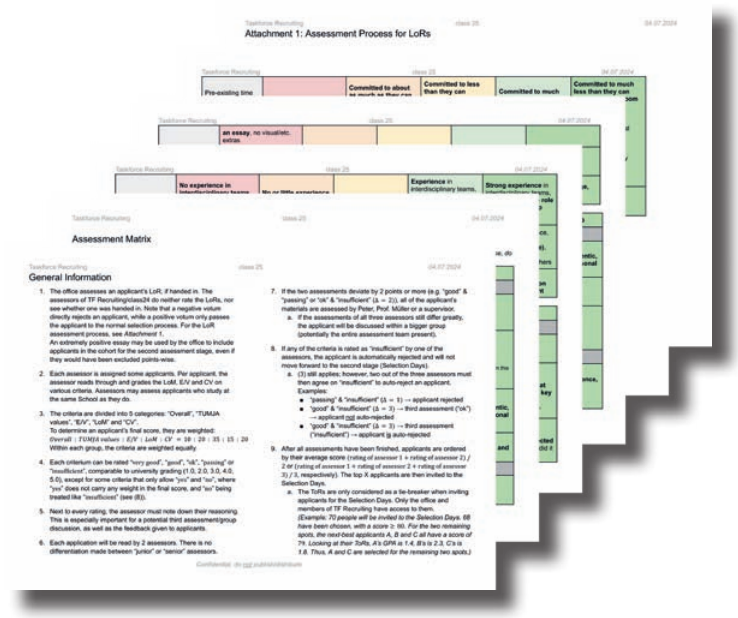
The end of a successful year as a member of the Taskforce Recruiting is marked by a thorough handover of the taskforce to the next generation of TUMJA members, which includes mentoring and doing work shadowing with the new taskforce representatives to make sure of a smooth transition into the new year.

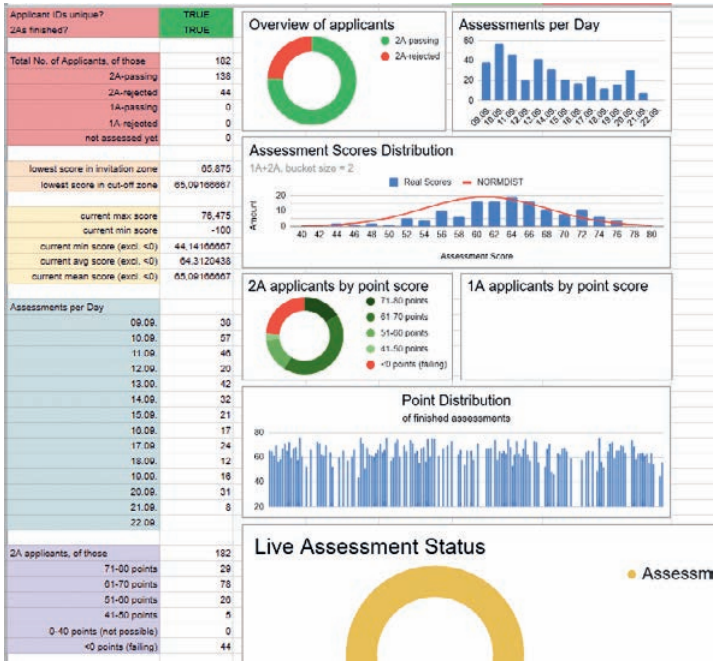
Class 2024
Saneblidze, Liza
Jacob, Eric
Baumann, Debora
Prock, Marius
Kellner, Maximilian Ludwig

Class 2025
Romy Coremans
Jacqueline Dellith
Shruti Dhoble
Roberto M. Silva Mercado
Shrutika Suhas Wadkar
Elena M. Teissier

Taskforce Seniors
Eric Jacob
Liza Saneblidze
Andrea Schittenhelm
Wolf Thieme


Closing
Thank you for participating in the Selection Days!


Attachment 1: Assessment Process for LoRs
Assessment Matrix
General Information


Applicant IDs unique? TRUE
2As finished? TRUE
Total No. of Applicants, of those 102
2A-passing 38
2A-rejected 44
1A-passing 0
1A-rejected 0
not assessed yet 0
lowest score in invitation zone 65.875
lowest score in cut-off zone 65.09166667
current max score 78.475
current min score -100
current min score (excl. <0) 44.14166667
current avg score (excl. <0) 64.3120438
current mean score (excl. <0) 65.09166667
Assessments per Day
09.09. 30
10.09. 57
11.09. 46
12.09. 20
13.09. 42
14.09. 32
15.09. 21
16.09. 17
17.09. 24
18.09. 12
19.09. 16
20.09. 31
21.09. 8
22.09.
2A applicants, of those 182
71-80 points 29
61-70 points 78
51-60 points 20
41-50 points 5
0-40 points (not possible) 0
<0 points (failing) 44
Overview of applicants
2A passing
2A rejected
Assessments per Day
Assessment Scores Distribution
1A+2A, bucket size = 2
Real Scores
NORMDIST
Amount
Assessment Score
2A applicants by point score
71-80 points
61-70 points
51-60 points
41-50 points
<0 points (failing)
1A applicants by point score
Point Distribution
of finished assessments
Live Assessment Status
Assessm

Taskforce Symposium

It's a sunny afternoon in July. In Herrsching, the scholarship holders of TUMJA have gathered once again for a seminar weekend. Everyone sits comfortably in a circle of chairs, facing a large whiteboard. At its centre, one thing is written and circled: "Symposium Class 24." "So, what are your ideas? What are your wishes?" a member of Taskforce Symposium asks the group. Almost immediately, a lively discussion begins. Ideas get exchanged, opinions are shared, and inspiration fills the room. By the end of the session, the Taskforce leaves with heads full of new ideas and wishes for the big evening.

As an interdisciplinary team, we now dive into the planning, execution, and creative design of the Symposium – with complete creative freedom and a shared goal: organizing a beautiful Symposium. The Symposium is an academic conference and the final highlight of the 20-month scholarship program at TUMJA. There, the project teams get the chance to present the research they've developed over their scholarship period to a wide and curious audience.

This year's Symposium will feature a diverse range of speakers, who will deliver interesting scientific talks on topics from all across the academic fields. Visitors will also have the chance to explore interactive booths hosted by the project teams, various student organizations, and the partners of TUMJA, Pixida, and Quantco – offering plenty of opportunities for exchange, networking, and conversation. And of course, there's room for fun, too: the event will be rounded off by a science-comedy performance by Magic Andy.

The taskforce's role in this event is just as diverse as the event itself, allowing each team member to contribute their creative ideas, organizational talent, and unique skills. In an iterative process – driven by constant feedback from the other scholarship holders – we decide on the program and vision for the evening. Beyond the content, we also take care of different organizational aspects, from choosing the location and catering to decoration, booth coordination, and inviting the speakers. Within the process, we were strongly supported by the entire office team – especially Peter and Dennis – as well as our taskforce seniors, Katharina and Paul. Thank you for all your support!

Class 2024
Abhirami Sreeprakash
Maja Benning
Konstanze Dietlmaier
Nicolas Ian Lugger
Olivia Jarosch
Vicente Mario Algaba Martínez

Class 2025
Mara Bud
Merlin Bieling
Ahmed Elhefnawy
Philip Groult
Jonathan Ross

Taskforce Senior
Paul Sieber

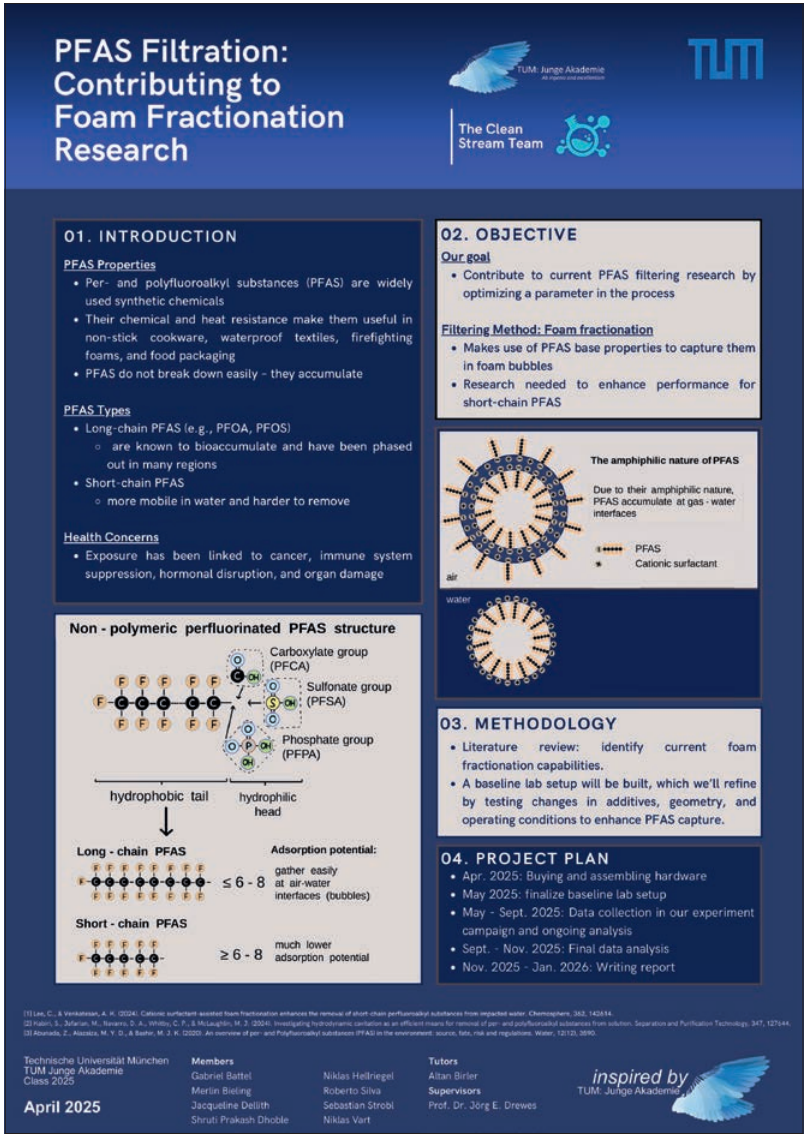

SYMPOSIUM
“What makes us human?”
THURSDAY, 5 JUNE 2025 | 17:00-22:00
TUMJA
#class2024
Project Presentations
Conference
Project Fair
Science Comedy
find out more!
TUM: Junge Akademie
Passion for science

Projects 2025

Projects 2025

The Clean Stream Team

How to tackle the PFAS problem



Building the team

The journey of our team began at the TUMJA kick-off weekend in November at the youth hostel in Wartaweil. After getting to know the other scholarship holders, the project and team-finding phase started with brainstorming sessions at different topic tables. Our initial group focused on renewable energies, the 'Not in my backyard' phenomenon, and other exciting ideas. After many discussions and exchanges, our table split into two groups: Team Hydrogen and the CleanStreamTeam.

What united us was the desire to build something tangible – something you can actually touch. Thanks to personal experiences shared by Jacqueline, Shruti, and Roberto, we quickly rallied around the idea of developing a water filter. Each of them was able to contribute meaningfully to the concept, as they all have relatives living in countries where access to clean drinking water is not a given, unlike in Germany.

With that shared vision, we left the kick-off weekend as the CleanStreamTeam: Jacqueline (Applied and Engineering Physics), Shruti (Environmental Engineering), Roberto (Environmental Engineering), Sebastian (Bioinformatics and Engineering), Merlin (Mathematics and Architecture), and Niklas H. (Quantum Science and Technology). With Altan, a former TUMJA scholarship holder, we also have a great tutor who can support our development as a team, as he has already gone through the same process. Over the following week, our team grew to eight members with the addition of Niklas V. (Applied and Engineering Physics) and Gabriel (Sustainable Management and Technology), who were not able to attend the kick-off weekend.

This was followed by several weeks filled with ideas, research, and discussions, until we agreed on the topic of PFAS filtration from drinking water during Future Lab 1 in January. Since then, we have settled on a specific method, which we now aim to replicate, study in greater detail, and explore for potential improvements.

A common challenge for a team of eight members is, of course, organizing meetings where everyone is available, especially with some team members abroad for research or exchange semesters. In addition, it was quite difficult to assess the feasibility of potential project directions. To support us in this, we brought in external expertise, such as Prof. Drewes, whose chair is already involved in PFAS removal research and is our team's supervisor now.

What's the problem with PFAS

As already mentioned, our goal is to contribute to the removal of PFAS from water. But why is this such a critical issue, and what exactly are PFAS? PFAS stands for Per- and Polyfluoroalkyl Substances, a group of chemical compounds known for their exceptional durability and resistance, used in various fields such as the fashion industry and firefighting foams. Because of their persistence, PFAS can enter the water cycle through the use of these products or during their production processes. Once in the drinking water, PFAS can accumulate in the human body, as they are not naturally broken down or eliminated. This accumulation can increase the risk of cancer, cause damage to the immune system, and disrupt hormonal balance. For instance, several cases have been documented where ski technicians exposed to PFAS developed cancer. PFAS contamination is a growing global problem, worsening each year because these substances are not degraded by natural processes for centuries. This is why they are often referred to as 'forever chemicals'. Our team aims to contribute to solving this problem by improving and studying a PFAS filtration method called foam fractionation. ■

Team

Gabriel Battel
Merlin Bieling
Jacqueline Dellith
Niklas Hellriegel
Shruti Prakash Dhoble
Roberto Silva
Sebastian Strobl
Niklas Vart

Tutor

Altan Birler

Supervisor

coming soon

Genbridge: Bridging Generations

Introduction
We are an interdisciplinary team aiming to connect students and recently retired professionals through meaningful research-informed relationships. Our goal is to bridge generations using technology, human connection, and data-driven matching – fostering growth, learning, and mutual respect.

Each year, companies lose critical tactical knowledge as experts retire, stalling innovation and efficiency (Schmidt & Muehlfeld, 2017). Meanwhile, older adults report rising social isolation and declining self-esteem (Orth et al., 2010), while students often lack access to real-world mentoring. Our solution is a structured intergenerational mentoring program that pairs students with experienced retirees, grounded in research on self-disclosure and intergenerational learning.

Why Bridging the Gap Matters

1. **Knowledge transfer:** Structured intergenerational mentoring preserves domain expertise (Pruett, 2020; Organization for Economic Co-operation and Development, 2024).
2. **Well-being on both sides:** Sustained cross-age contact yields small-to-moderate gains in older adults' mood and purpose, while students gain self-efficacy (Krzeczkowska, 2024).
3. **Social cohesion:** Reciprocal disclosure reduces prejudice across age, race, and occupational lines (Turner et al., 2007).

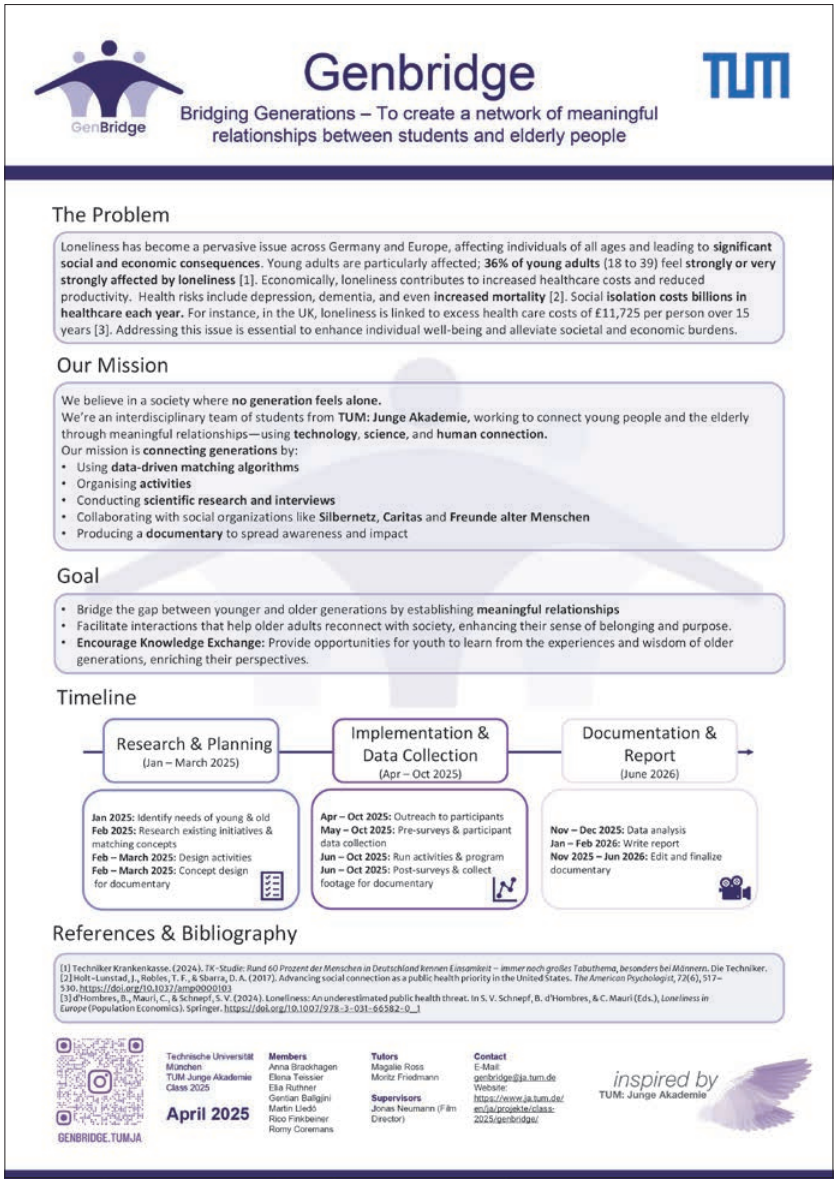
Mentoring Program

- **Professional layer:** For example, a retired BMW engineer might be matched with a mechanical engineering freshman passionate about car manufacturing. Ideally, each mentoring pair commits to regular sessions and additional optional community activities.
- **Social layer:** Pairs receive discussion prompts rooted in the 36-question procedure introduced by Aron et al. (1997) for increasing social connection. We will further adapt the questions to focus on generational perspectives.
- **Storytelling & outreach:** With consent, we will document select moments and compile a short documentary film to showcase the insights, laughter, and meaningful conversations that arise when generations truly listen.

Research Methodology

Phase	Method	Key Metrics
Pre-test	Online survey (Likert scales)	Perceived closeness (IOS), ageism, self-efficacy
During test	Session logs + voluntary short interviews	Engagement, topic breadth
Post-test (T1)	Repeat survey + semi-structured interviews	Closeness, knowledge gained, well-being
Follow-up (T2, 3 mo.)	Survey	Retention of ties, ongoing contact

Contact
Are you a retiree full of insights – or a student hungry to learn? Contact us at genbridge@ja.tum.de or learn more about the project on https://www.ja.tum.de/en/ja/genbridge/. ■



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Team

Anna Brackhagen
Elena Teissier
Elia Ruthner
Gentian Ballgjini
Martin Lledó
Rico Finkbeiner
Romy Coremans

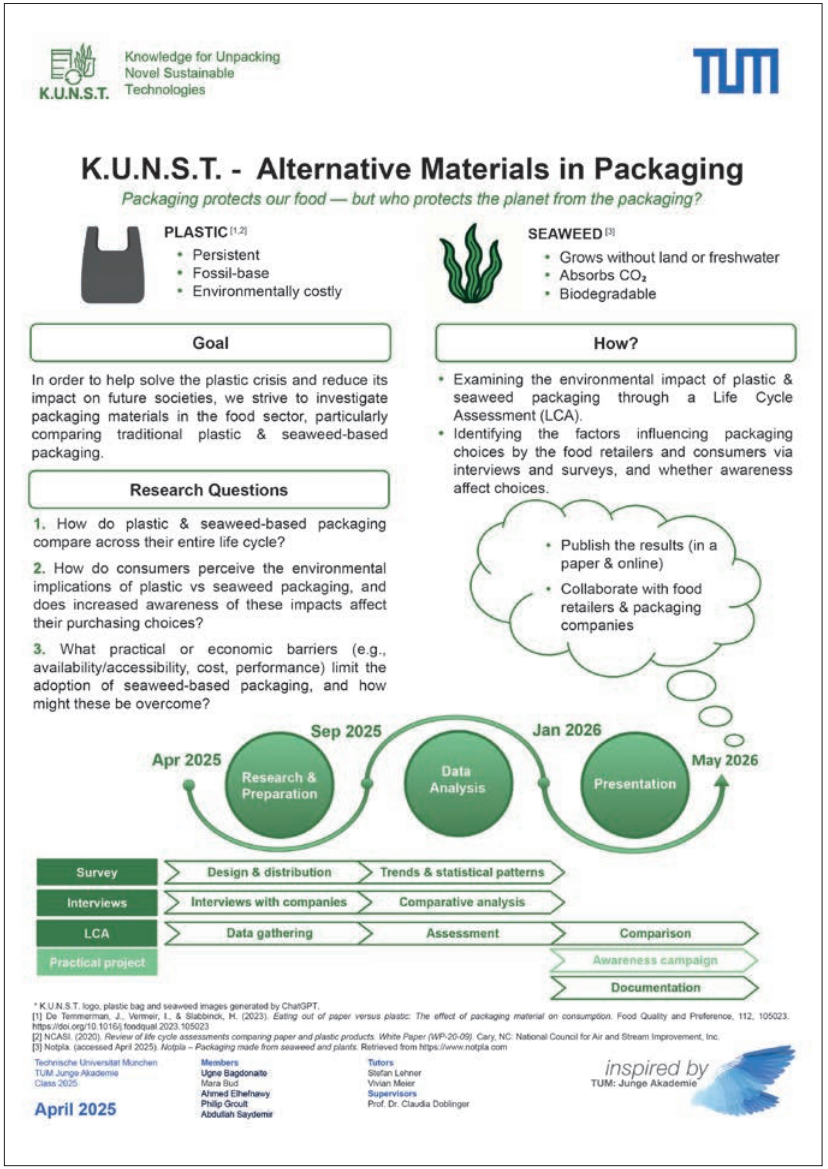
Tutors

Magalie Ross
Moritz Friedmann

Supervisor

Jonas Neumann
(Film Director)

K.U.N.S.T.



As members of TUMJA's class 25, we had to ask ourselves which topic concerning future societies we wanted to delve into. In our opinion, the plastic crisis is a major problem to solve for the benefit of societies, as it causes large quantities of waste, such as the Pacific garbage patch, along with a huge loss in biodiversity, and recent studies even suggest that we all have plastics within our brains. Therefore, we decided to tackle this issue by investigating packaging materials, as packaging in the industrial sector produces the highest amount of plastic waste. We decided to limit ourselves to the food industry, more specifically to single-use packaging, as this is one of the major contributors to plastic waste and one that directly affects our daily life. Thus, we went looking for alternative and recyclable materials to replace plastic. After comparing various options such as beeswax cloths and mushroom-based packaging, we settled on seaweed-based packaging due to its affordability, low CO2 and water cost, as well as its compostability. Consequently, we intend to make a more thorough comparison of the impact of these materials using a Life Cycle Analysis (LCA) and probe into the key factors influencing food retailers and consumers in their packaging choices. This step will be achieved through interviews and surveys, thus allowing for a three-pronged approach to the topic, resulting in a wide-ranging and varied overview of those packaging types and their current and future use. Throughout our project, the data will be made available to the public through our webpage. Finally, at the end of it, we aim to implement an awareness campaign or a pilot project for the long-term replacement of single-use plastic packaging by novel seaweed-based packaging.

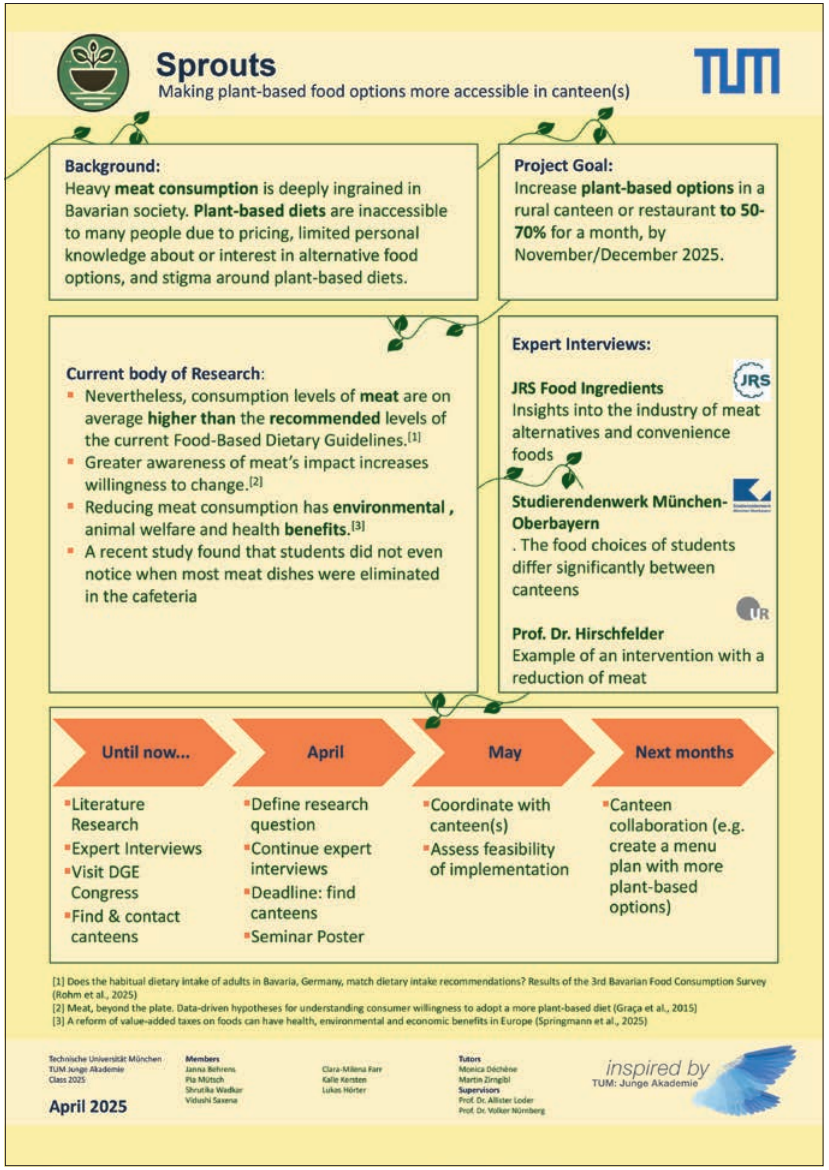
Our team presents a multicultural background, with its members studying in various fields of engineering and sustainability. We named ourselves Team K.U.N.S.T., as a backronym for “Knowledge for Unpacking Novel Sustainable Technologies”. Additionally, the name refers to the German words for art (Kunst) and plastic (Kunststoff), and so is intended to encourage readers to reflect on the links between art and packaging. By pondering this question, the reader already engages with a major aspect of art, which is to convey ideas and encourage reflection. We tend to see packaging as a convenient tool we take for granted; once it has served its purpose, it is discarded, and the consequences forgotten. But we aim for each of us to ponder what happens afterwards and where the plastic may end up. While plastic packaging protects our food, who protects our planet from the packaging? ■

Team
Ugne Bagdonaite
Mara Bud
Ahmed Elhefnawy
Philip Groult
Abdullah Saydemir

Tutors
Stefan Lehner
Vivian Meier

Supervisor
Prof. Dr.
Claudia Doblinger

Sprouts



Our Motivation

The climate crisis affects us all - and agriculture is one of its major contributors. Most of the environmental damage that is associated with our food traces back to animal products. For example, soy cultivation, often criticized for its devastating environmental impact, is primarily used to feed livestock rather than people directly.

The Third Bavarian Food Consumption Study (BVS III) has shown that meat consumption is still deeply rooted in Bavarian society. Despite well-documented negative effects on health, animal welfare, and the environment, the average meat intake continues to exceed recommended levels.

Our Project

Research has shown that a greater awareness of meat´s impact increases the willingness to change. Our interdisciplinary team aims at evaluating people's meal choices in the context of communal catering, with a special focus on corporate canteens in rural Bavaria. Our goal is to promote healthier and more sustainable eating hab-

its by increasing the share of plant-based options in a canteen to 50–70% for a month by November 2025.

Through literature research and multiple expert interviews we gathered insights into the current situation, learned about similar projects, how we should approach the problem we identified and what to keep in mind.

Using choice architecture, we want to test whether a greater availability of vegetarian and vegan meals on the menu influences decision-making. Do people stick to convenience foods, or do they prefer trying unfamiliar dishes? How important is it, actually, that a meal contains meat, and what influence does the placement in the canteen have on meal selection? Rather than imposing our views, we seek to inspire change and explore practical solutions — motivating others to try plant-based diets through opportunity and experience.

We hypothesize that increasing the ratio of plant-based to meat options would increase the consumption of such meals.

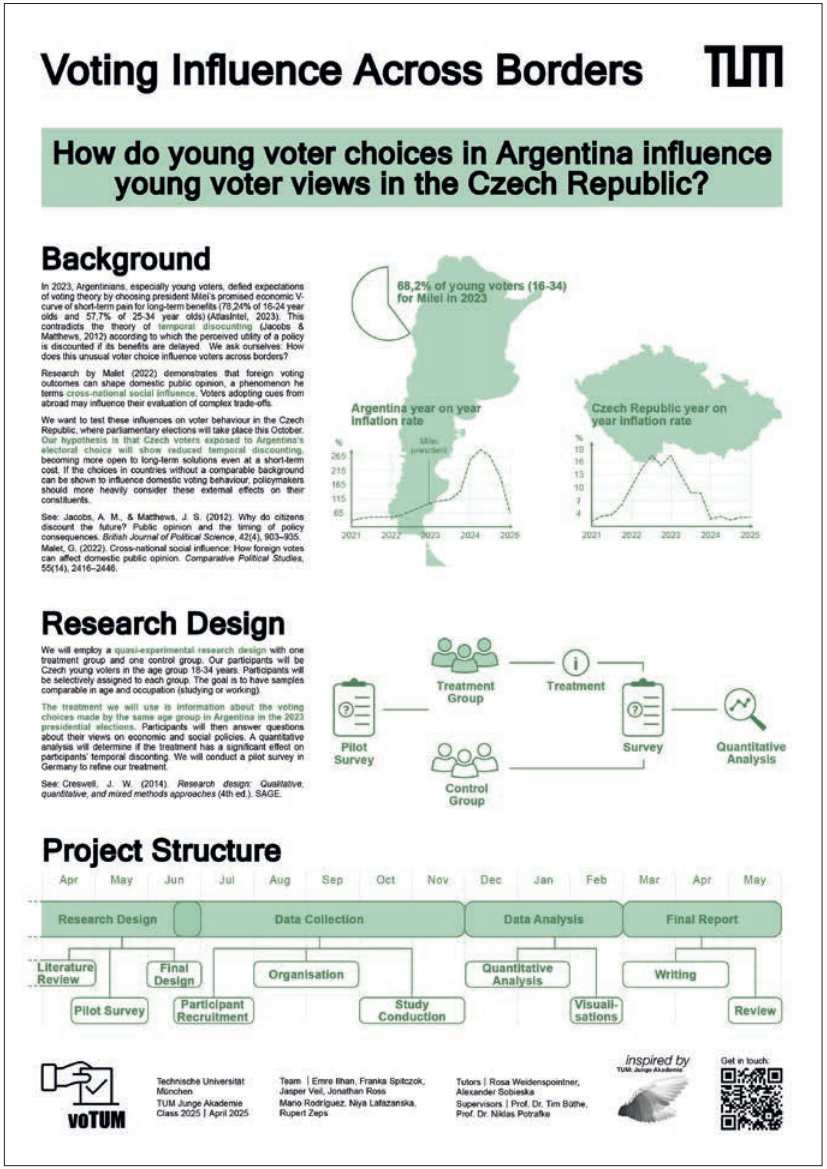
More about our project and its status: www.ja.tum.de/ja/projekte/class-2025/sprouts/

Team
Janna Behrens
Pia Mütsch
Clara-Milena Farr
Lukas Hörter
Kalle Kersten
Vidushi Saxena
Shrutika Wadkar

Tutors
Monica Déchène
Martin Zirngibl

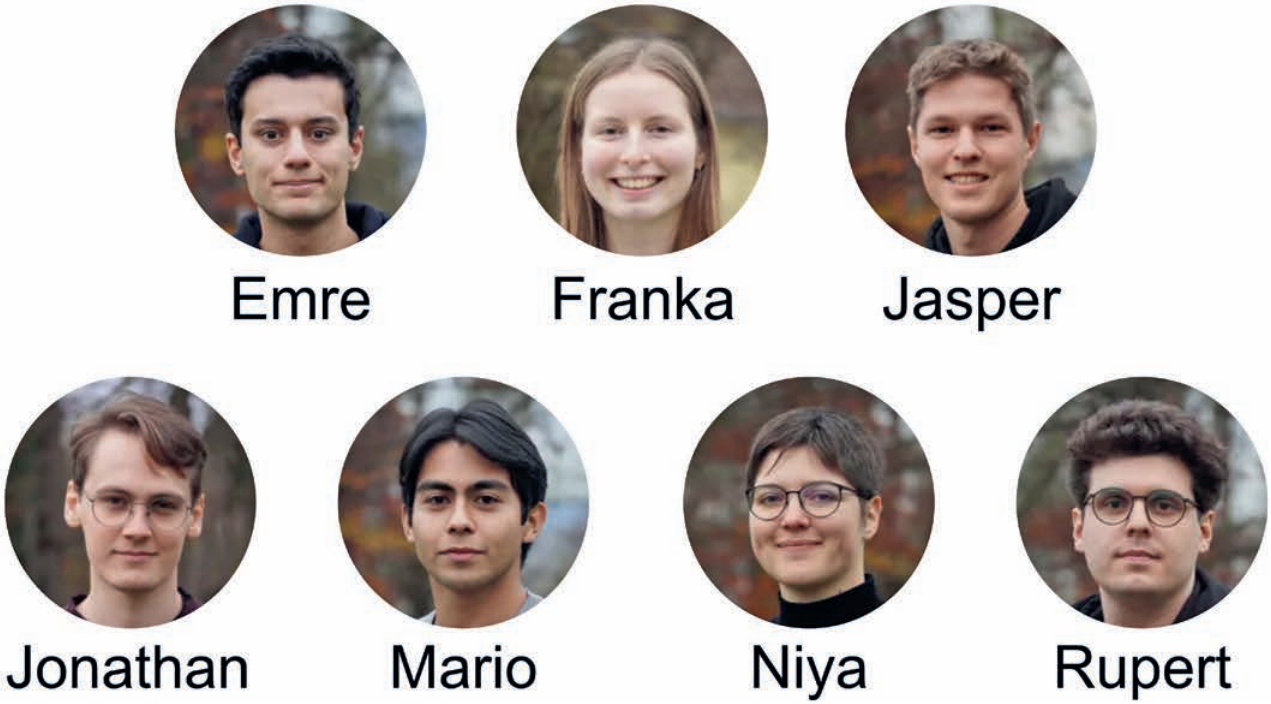
Supervisors
Prof. Dr. Volker Nürnberg
Prof. Dr. Allister Loder

voTUM



We are an interdisciplinary and intercultural team united by a shared passion: Understanding voting behavior. Team voTUM, that's Emre Ilhan (B.Sc. Electrical Engineering), Niya Lafazanska (M.Sc. Urbanism), Mario Alberto Rodríguez Cervantes (B.Sc. Physics), Jonathan Ross (M.Sc. Electrical Engineering), Franka Spitczok von Brisinski (B.Sc. Informatics), Jasper Veil (B.Sc. Management & Technology) and Rupert Zeps (M.Sc. Politics & Technology).

Historically, researchers have often relied solely on domestic indicators to explain voter preferences. However, recent research has shown that decisions of voters abroad may also influence domestic voting behavior in an increasingly interconnected world. Additionally, voters tend to act according to the theory of temporal discounting, preferring policies with a short time horizon over ones that take a long time to show results. Both cross-border influence and temporal discounting are important for current leaders making long-term decisions on issues such as tax reform. Our goal is to offer insights into how exposure to global political narratives affects voters' evaluation of long-term economic and structural reforms at home.



We are particularly interested in young voters' behavior, since they are likely to experience both the short and long term effects of political decisions. We want to employ a quasi-experimental research design using information treatment. A treatment group will be given information about elections abroad, in which voter behavior contradicted the implications of temporal discounting. The treatment group's tendency for temporal discounting will be compared to that of a control group which is not treated with any information. We hypothesise that the treatment will lead to reduced signs of temporal discounting.

We would like to test our hypothesis on young voters in the Czech Republic. The Czech parliamentary elections are expected to take place by October 2025. Since voters have been shown to be more politically engaged in the time leading up to an election, testing our hypothesis during this time will help us to separate priming effects from learning effects. In a pre-election environment, where voters are more frequently surveyed, we hope to collaborate with researchers already dealing with voter behavior. ■

Team

Emre Ilhan
Niya Lafazanska
Mario Alberto Rodríguez Cervantes
Jonathan Ross
Franka Spitczok von Brisinski
Jasper Veil
Rupert Zeps

Tutors

Rosa Weidenspointer
Alexander Sobieska

Supervisors

Prof. Dr. Tim Büthe
Prof. Dr. Niklas Potrafke

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The respective authors are responsible for pictures and graphics in the research reports.

Address TUM: Junge Akademie
Arcisstraße 21, 80333 München
Tel +49.89.289.22064
Fax +49.89.289.22870
jungeakademie@zv.tum.de
ja.tum.de

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