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## **TUM: Junge Akademie**

Research Reports 2022 Learning from Nature

## **TUM: Junge Akademie**

Research Reports 2022

Partner of



Freunde der TUM Association of Alumni and Friends

### Welcome to the TUM: Junge Akademie



This booklet "Research Reports 2022" describes the work of the five student research groups that kicked off in November 2021 in the extremely inspiring large lecture hall of the Botanic Garden in Munich. After 2 ½ years of restrictions in our personal lives, we had come together again for the first time for a kick-off event. There was a very special sense of excitement and motivation in the air, both among the scholarship holders and among us who bear responsibility for the TUM:

Junge Akademie, and the location could not have been more appropriately chosen in accordance with the year's call: "Learning from Nature."

The thirteen members of the Advisory Board – six representatives of the scholarship holders and six representatives of the professors, including the President of the University of Television and Film, Bettina Reitz, and the President of the University of Music and Theatre, Bernd Redmann, as well as myself as Vice-President of TUM and ex officio Director of TUMJA – had worked this out from a series of internal proposals in spring 2021. Today we can see clearly that our expectations were more than met. The results of the five teams presented here, composed of scholarship holders from all schools of TUM, are convincing not only for us but also for the partners of the projects, as well as for the scientific community, as evidenced by the admission of one of the teams to the 9th International Conference on Computational Social Science at the Technical University of Denmark in July of this year.

It is not an easy task for a heterogeneous, diverse, and interdisciplinary team to transform a very open call like this from initial ideas to tangible results. This requires a high degree of openness, communication skills, commitment, and perseverance, and at least to the same extent the ability to reflect on one's own actions, ambitions, and current developments. We rely on these competencies, or at least on building them up, in our scholarship holders. We expect them to be willing to work together in open teams and to examine and develop themselves and their fellow students in the process. Today, twenty months after the start, all #class22 scholarship holders can rightly and proudly claim to have developed further. The time at TUMJA was demanding, sometimes exhausting, but always rewarding and enriching. Moreover, the Student Research Project is only one of six current learning formats from which the scholarship holders, as well as the alumni, benefit. Commitment in one of seven taskforces, in which the scholarship holders take personal responsibility to shape and steer TUMJA, is obligatory for all active participants. In addition, activities as moderators, trainers, tutors, as well as mentors, are options for all those involved in the network to test and strengthen their own skills.

If we count the years of the predecessor program "Experienced Paths to Research," which was founded in 2004 by the two current Emeriti of Excellence, Prof. Bertold Hock and Prof. Paul Gerhardt, as a networking and support program for scholarship holders at TUM, next year we will be able to celebrate the twentieth anniversary of early targeted support for young scientists at TUM. Most of the scholarship holders are in their early twenties when joining the program. Almost 700 people have already benefited from the program, many of whom have successfully arrived in academia and are now preparing new generations of students with enthusiasm and conviction for the interesting and demanding life after graduation. I would like to take this opportunity to thank the many dedicated mentors and tutors. Their work has had an impact like hardly anything else they could have done in place of their commitment to TUMJA.

I wish you a cross-generational and cross-disciplinary insight into the wonderful year of #class22, and I am already looking forward to our anniversary in 2024 and the powerful future of our program.

Yours sincerely,

Jehn for

Gerhard Müller Vice President for Academic and Student Affairs

## ПП

## Dear TUM fiends and associates,

One of the most powerful, I say even magical things about TUM is that we are a prime destination for talented, self-determined people from all over the world. No other university in Germany has that kind of pull on people's imaginations and ambitions. We are a place that encourages curiosity and creativity, creates personal growth opportunities, and enables people to collaborate with others. There are thousands of top national and international students on our campuses getting a world-class education experience; we are lucky they chose us.

Our aim is to ignite an entrepreneurial spirit, expand learning horizons and generate outstanding academic achievements. Therefore, we not only impart the necessary scientific and technical knowledge to our students, but also a more profound sense of purpose in life. We not only provide skill-sets suited to industry needs, but also well-rounded perspectives needed for future innovation. We recognize that secondary education does come with financial obligations, and hope that the funds offered by TUM Junge Akademie will help students succeed in achieving their career of choice.

This year's five exciting projects are a testament to these goals: Aesthetics have designed a finger prosthesis and developed several prototypes using a 3D printing process, as it is not yet common to provide "micro amputations" with prostheses. A topical issue is being dealt with in project VINFO: they are investigating the language of misinformation in the lateral thinking scene, and they have now been invited to DTU with their topic at a conference in Copenhagen. CheckMate investigated the competencies of students in grades 10-12 to recognize fake news and developed a "training" app to help promote these competencies. Membrains began with the concept of a microplastic filter based on the gills of the manta ray. The team is currently working on scaling the principle for application in micro-hydro power plants to make them more fish-friendly.

I want to thank our extensive interdisciplinary partner network – the HFF Hochschule für Fernsehen und Film, the Hochschule für Musik und Theater, and the Akademie der Bildenden Künste.



As President of TUM, I would like to thank everyone for the time, effort and commitment you invest each year in the promising talents of TUM Junge Akademie. Because of you, our university continues to produce scholars, dreamers and leaders who benefit the entire world. I am looking forward to continuing this success story with you in the years ahead.

Yours sincerely,

F. Cofan

Thomas F. Hofmann President

## "In nature nothing exists alone."

Rachel Carson (1907-1964)

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## Learning from Nature

This year's overarching call "Learning from Nature" opened up a wide range of perspectives: from the research fields of bionics and biomimicry to questions of economic and social systems and the interaction of individuals in swarms. The call provided our student research teams with a starting point for five very different journeys into research and science. The results of these explorations are summarized in this book.

#### **Passion for Science**

There are many supporting factors in getting to grips with science, and one of the most important ones is passion. The TUM: Junge Akademie offers passionate and committed students the opportunity to engage seriously with science for the first time. Their curiosity and desire to explore and fully immerse themselves in scientific issues is what unites TUMJA's scholarship holders. Being passionate about science helps students to face constant new challenges, to break down complex topics into manageable segments of knowledge and to recombine them into a coherent picture later on. With their projects, the TUMJA scholars contribute significantly to science and, at the same time, this contribution to science accomplishes an important contribution to society. TUMJA aspires to promote its scholarship holders in an integrated manner. Using the 20 months' duration of the program, the students and doctoral candidates plan and develop a self-chosen project within an interdisciplinary team. Our scholarship holders aim to find solutions for social issues, to enable creative innovations, and to review these in relation to their feasibility. Throughout this process, they are supported by top-class researchers who guide them from initially substantiating their project idea through to concluding it as a final project report. Various workshops, such as for scientific and journalistic writing or project management, accompany the project work.

#### **Commitment to the Program**

In addition to project work, the TUMJA scholarship includes an extensive supporting program with community and networking-forging events, inspiring excursions, and more. What makes this program so special is that the scholarship holders largely design it themselves, contribute their expertise to taskforces and, by doing this, develop their knowledge and personality. With their diverse skills and determined commitment, the scholarship holders also contribute to major events such as the TUM Science Hackathon, the TUM Campus Run or the annual Symposium.

## **Facts and Figures**

The exceptionally talented and committed scholarship holders and alumni of the TUM: Junge Akademie reflect a great diversity in many ways. The class of 2022 represents a wide range of social, cultural and, above all, academic currents at TUM.

During the selection process for this class, an average of 10 percent of all TUM students – the most outstanding in their fields – received a nomination to apply for a TUMJA scholarship. At three information events, interested students were able to get a detailed picture of what TUMJA has to offer. Eventually, TUMJA received 108 applications from nominated students. In a multi-stage application process, 76 young talents went through interviews regarding their motivation for science, research, and interdisciplinary cooperation and were invited to prove themselves in small work assignments. At the end of the selection days, 46 scholarship holders were accepted into the class of 2022.

After 20 months of enriching and valuable experiences, 34 students successfully completed their TUMJA scholarships. See their portraits on pages 27 – 32. 22 male and 12 female scholarship holders successfully completed their scholarships.



TUM: Junge Akademie

## Medicine Biochemistry

Health Science - Prevention and Health Promotion Mathematics Physics PhD in Life Sciences Engineering Science

## Electrical Engineering and Information Technology Molecular Biotechnology Mechanical Engineering Sport and Exercise Science

Politics & Technology

Engineering / Mechatronics and Robotics

## Information Systems

Materials Science and Engineering Architecture

Management and Technology Informatics

The innovative and creative ideas of the teams also grow through interdisciplinary interaction. This year's scholarship holders come from 19 different fields of study from all TUM schools.

#### **Expected Study Degrees**

In addition to new subject-related insights, younger scholarship holders in particular benefit immensely from working with more experienced students who have already gained an insight into the world of science. This year, nine Master's students, three students with state examinations and one doctoral candidate were happy to share their knowledge with 21 Bachelor's students. During the scholarship period, 8 scholarship holders finished their Bachelor's and began a Master's program and four scholarship holders started a doctorate.





The diversity of the scholarship holders is also apparent in their origins, as the chart above illustrates. The different international influences within the class opened up new perspectives and enriched the interdisciplinary cooperation with important intercultural aspects.

## **Mentoring Insights**

#### The very individual and special offer for the scholarship holders

One of the great advantages of TUMJA is the extensive network it offers its scholarship holders. It consists of over 700 members, including active scholarship holders, alumni, various experts from the industry, and numerous professors, whose contributions and involvements vary within the program.

The TUMJA internal mentoring program, launched in 2019, provides the scholarship holders with a very individual, additional offer: A one-on-one mentorship by a TUMJA alumni or an experienced scientist. It does not matter whether the tandem partners are onsite or spread across the globe: Experience shows that trust and friendship can develop and endure across continents.

We thank all mentees and mentors for their openness, commitment, and trust in each other. Our thanks also go to Taskforce Mentoring for planning and organizing the TUMJA Mentoring program!

Read more about Taskforce Mentoring on page 172.

#### The Mentoring Tandems of the Class of 2022 and their Experiences during the one-year Mentoring Program

Kathrin Schmalzl (left, Mentee of Prof. Dr. Dr. Jürgen Beckmann, Emeritus of Excellence): "I would like to express my gratitude and appreciation to Jürgen for his continuous dedication and commitment to my academic and personal progress. I find Jürgen to be a unique, infectiously enthusiastic and highly knowledgeable individual with a great personality who has inspired and motivated me in such an empathetic way. I am glad that I had the opportunity to get to know Jürgen and I am looking forward to all that may come. A big thanks to Jürgen!"





Til Hagendorn (left, Mentee of Stephan Wolf): "Stephan helped me to become aware of what is the right path for me. Thanks to the open exchange with him and sharing his perspective, I found my dream job for my upcoming steps."



Sophia Duggen (below, Mentee of Dr. Juliane Hafermann): "The conversations I had with Juliane were always very comfortable and at the same time extremely insightful for my professional life. Being in the same field of study but having much more experience, she was able to give me a lot of helpful understanding about career options in biotechnology which was eye-opening to the point that I am now considering doing something different from research. I really appreciate the honest and open atmosphere and Juliane's patience in answering all my questions."



Rosa Weidenspointner (right, Mentee of Ann-Christin Villegas): "The mentoring program offered me the unique opportunity to exchange ideas with a successful woman with a similar scientific background. I very much appreciate our inspiring conversations."





I'd like to say a huge, special thanks to Dr. Jana Ellegast who showed constant engagement and commitment towards my personal and academic success. As a woman. I look up to her how well she manages family, an advanced career path, passions, and living and working in another country. Moreover, she advised me in mv Master thesis as well as opportunities after my graduation. Cheers to a continued mentorship and friendship!

Sophia Leiss, MS TUM

Learning from and sharing some of my experiences with the next generation of leaders in life and health sciences is one of the greatest privileges of my professional life.

Jana Ellegast, MD Instructor, Harvard Medical School





Prof. Andrzej Buras, EoE (left, Mentor of Zied Jaber): "Zied M. Jaber impressed me by his interest in particle physics. He started reading my book on Weak Decays that is more for phD students than bachelor students. On the basis of several meetings we had, he understood much more from what he read than I expected from somebody of his age."

Zied Jaber (right, Mentee of Prof. Andrzej Buras, Emeritus of Excellence): "I cannot overstate how much of a privilege it is to work with Prof. Buras. Being able to exchange and learn from such an exceptional physicist has been a real blessing. Prof. Buras always finds the time to explain everything. I have learned so much just by being around him and I am sure the best is yet to come."

## Alumni Interviews

#### **Prof. Dr. Maximilian Schreieck**

In an interview with Euridice Pinheiro Vieira Harke and Flavio Principato



#### Short CV:

- TUMJA class 2011
- Bachelor and Master in Management and Technology, TUM
- Doctorate with focus on Information Systems at TUM
- Assistant Professor, Information Systems, in particular Digital Services and Platforms at University of Innsbruck

## What drives you in life or what are you passionate about?

What consistently motivates me in my professional life is the joy I find in learning new things and sharing that knowledge in some form or another. This was true back in school when I worked as a private tutor and this passion continued as I took a teaching assistant job during college. Throughout my Ph.D., I was heavily involved in teaching and supervising thesis work, and now, of course, here in my role as an assistant professor at the University of Innsbruck. The great thing about it is that we have a lot of freedom in choosing the topics we cover and teach. Discussions with students often also lead to new subjects and questions, making each day a little different and never boring. That is what excites me.

## You did your bachelor's and master's degrees in business administration at TUM and then switched to business informatics for your Ph.D. What has led to this decision?

The fact that I made this transition is indeed closely connected to the TUM Junge Akademie. The Chair of Prof. Krcmar where I pursued my doctorate was the same chair we collaborated with on the TUM Mitfahrer-App (ride-sharing app), which was our TUMJA project at that time. In fact, both I and another team member from the TUM-JA project started our Ph.D. studies at this Chair as there were openings for positions being created for interesting projects. The focus was on a mobility platform for a Smart City, initially based on Dresden as an example, which provided thematic relevance where I could build upon.

#### After being a scholarship holder at TUM-JA in 2011, you returned in 2015/2016: this time as a tutor. How did you perceive this role and what can you recommend to future teams and tutors?

In the Picturise project, the aim was to explain everyday things simply through pictures. This project emerged under the influence of the increased immigration of refugees in 2015 and had similarities to the Integreat project I was working on at the time. Overall, from a tutor's perspective, I found it fascinating to witness how a diverse team comes together, enters a mode of collaboration, and collectively creates something.

One challenge as a tutor is to find a balance between supporting and allowing the team to develop without imposing one's own ideas on the process. To achieve this, it is necessary to clarify the role of the tutors early on in the process, aligning it with the expertise of the individuals, the team, and the project. I believe that by doing so, the team and the tutors can establish a setup in which they complement each other.

#### **Natalie Eisenhut**

In an interview with Aastha Chandiwala and Seong-Min Jun



#### Short CV:

- TUMJA class 2014 / 2015
- B.Sc. in Information Systems and M.Sc. in Computer Science, TUM
- Director Ecosystem Consulting at Celonis

When we researched your career path in preparation for the interview, we were very impressed by the fact that you rose from a junior analyst position to your current position as Director of Ecosystem Consulting within four years of obtaining your master's degree. Looking back, does that amaze you at all?

Sometimes, when I look back, I do think to myself, "Wow, that's impressive." I never thought that I would go through so many stages in such a short period of time. I never specifically aimed for it either. I believe I was just fortunate with my initial career choice, which was a good fit for me. It allowed me to combine all my strengths, from my technical background to the business side, as well as the social aspect, sales mindset, and more. That gave me a good start and laid incredibly solid foundations. Additionally, I believe that the key to rapid growth and development is to venture into areas where there is a lot of growth happening. An example of that was when I traveled to Japan and built the team for Celonis. That experience provided a fantastic foundation for me subsequently to move into team leadership. After that, I actively sought out the next exciting mission. But I am even surprised myself at how quickly it all happened.

#### You did your bachelor's and master's degrees at TUM. Which experiences from your time at university helped you most in your career and success?

I am a goal-oriented learner. I enjoy learning things with the intention of applying them afterwards. That was something I found to be frustrating during my studies, but now in the professional world I really appreciate it because I get to have this immediate translation of knowledge into concrete action. However, what has immensely helped me are the many insights into different fields and subjects that I have gained. Having a certain vocabulary has been beneficial, as it has allowed me to guickly grasp new topics later on. For example, I may not have been proficient in SQL immediately after a lecture, but I could quickly acquire that knowledge on the job because I had a foundational understanding from university. Another important skill that I have taken away from that time is the ability to familiarize myself with new areas. Simply because I spent five years learning how to acquire a lot of knowledge within a short period.

#### Do you have any piece of advice or words of wisdom that you would like to pass along to our scholarship holders?

There is one thing that I slightly regret or would change if I could. I could have used my time during my studies to travel and try new things more because it becomes much more difficult to take longer breaks later on. I took everything very seriously, thought a lot about the future and wanted to do everything the best way possible, which, of course, helped me start a successful career. Ultimately, no one really cares whether you are better or worse by a decimal point. What matters more is the experiences you have had. Especially traveling abroad, pursuing hobbies, and so on, are things that shape your character and provide the most important foundations. That would be my main advice: Make the most out of your life and do not work too hard. I am making up for it now. but it is much more stressful. \*Laughs\* 

#### **Elena Corella Puertas**

In an interview with Niclas Weddigen in April 2022



#### Short CV:

- TUMJA class 2013
- Study of Chemical Engineering at TUM
- Doctorate at McGill University in Montreal, Canada
- Postdoctoral Researcher at the International Reference Center for Life Cycle Assessment and Sustainable Transition (CIRAIG)

#### How did you become interested in chemical engineering? What fascinated you about it to the point where you wanted to study it and continue pursuing it until obtaining a doctorate?

At the end of high school, I was not sure what I wanted to pursue because I was passionate about so many different things. Ultimately, I saw myself as an engineer and chose chemical engineering since chemistry was one of my favorite subjects in school. Prior to starting my studies, I had the idea that as a chemical engineer, I could directly contribute to environmental issues. However, during my studies, I realized that it was not directly related to the environment. Nevertheless, I continued with the Master's program. Fortunately, during my doctoral studies and now afterwards. I am once again working in the environmental field, which makes me very happy.

#### Did you already have an interest in research during your time in Germany or did you realize your passion for research later on in Canada?

My interest in research actually began during my time in Germany. As part of my studies, I wrote several research papers, including my bachelor's thesis, two semester papers, and my master's thesis. It was also fantastic that I was given the flexibility to participate in multiple exchanges during my studies in Munich. During my time in Brazil, I worked on a very interesting semester project that further sparked my interest in research. When I went to Canada for my master's thesis, I knew that I wanted to pursue a doctoral degree afterward. I didn't know where exactly, but the thought was already there. Working on my doctorate further confirmed my love for research, and I continued to pursue it. It gradually developed, starting during my time at TUM.

#### Is there something in particular that stands out to you about your experience at the TUM Junge Akademie, something that was particularly memorable?

Two things come to mind. With our team EsperanTUM we organized a "Mini World Cup." I really enjoyed the organization and the event itself. Students from different countries came together to play football. Afterwards, we went to a bar and watched a World Cup match together, as it was taking place at the same time. The atmosphere was fantastic.

Additionally, I participated in the TUMJA mentoring program "Buddies for Refugees" in 2015. I was involved for the first four months before I moved to Canada. We were highly active every weekend, and the motivation was incredible. The atmosphere was so positive, and we were able to make a real impact. I always looked forward to the weekends because of that.

#### Prof. Dr. Viktor Kölzer

In an interview with Judith Paripović and Paul Sieber in September 2021



#### Short CV:

- Previous TUMJA program "Erfahrene Wege in die Forschung"
- Study of Human Medicine, TUM
- Doctorate (Dr. med.), LMU
- Postgraduate Certification in Medical Genomics (Univ. Birmingham)
- Board Certified Pathologist FMH
- Attending Pathologist and Lead in Digital Pathology, Universitätsspital Zürich
- Professor for Digital Pathology at University of Zurich (UZH)

#### You currently live and work in Switzerland. Did you move abroad for professional reasons?

I gained international experience relatively early on. When I was 13, my parents and I moved to USA for three years, and I attended the High School there. This very positive experience taught me to always look outward, to be open to new things, and to adapt quickly to a new environment. Throughout my studies, international stays were always highly motivating for me. From New York at the Presbyterian Hospital, to the Children's Hospital in Boston, to Karolinska Institute in Stockholm, and now here in Switzerland, I have always found it incredibly inspiring to learn new things. The guestion of "Where do I want to pursue my career after university?" also played a role in planning study visits. Switzerland offers highly gualified levels of educational provision and a very open research landscape, with excellent funding opportunities, and it is known for its cultured and self-responsible community life. The diversity, the presence of four language regions, the positive interaction, and the mutual respect make Switzerland an attractive place to live.

#### You have been in many countries and gained varied experiences there in the world of science. What are the differences in the scientific field between countries?

In a professorship, by definition, one has a certain "scientific freedom" to develop one's own research topics. This freedom is necessary in science to independently pursue new ideas. I have experienced this as a fundamental paradigm in all the countries I have lived in. The actual differences often lie in the details: "What are the funding opportunities? How is the importance of science perceived in general?" In summary. I can say that all the countries where I have lived and worked - USA, Germany, Switzerland and England - are very good locations for scientific research. Science is socially valued, there are good opportunities to obtain funding, and as a young scientist, there are good opportunities for personal development. It is important to find your own research topic and to stay committed even during challenging times, to keep your eyes open and proactively engage. Academic medicine is a demanding but very interesting field that allows for the integration of clinical work and engagement in scientific research.

#### Do you have any advice for young people studying at university? What should they consider, what should they do, and what should they avoid?

One should always follow one's passion. For me, it was the opportunity to go abroad early on and have that exposure. Scholarship programs such as the TUMJA program "Experienced Paths into Research" provide excellent opportunities for this – getting involved in such programs, being part of the exchange, and broadening one's horizons is important. It is also essential to be aware that life paths are dynamic and diverse. New opportunities and chances will arise, and not everything can be planned in advance.

### The Boards of the TUM: Junge Akademie



#### **Advisory Board**

Since the Academy's foundation in 2010, the Advisory Board represents the organizational unit of the TUM: Junge Akademie with decision-making power. The Advisory Board represents the Academy's governing body, whose members meet twice a year. Such meetings are important to ensure sustainable growth and overall effectiveness of the Academy. The Advisory Board primarily decides on the medium- to long-term strategic and organizational issues of TUMJA. In November 2022 the new President of the University of Music and Performing Arts Munich, Prof. Lydia Grün, joined the Advisory Board. She succeeded Prof. Dr. Bernd Redmann, who had enriched the collaborative nature of the Advisory Board since 2016. Also since 2016, Prof. Bettina Reitz, President of the Munich University of Television and Film, has been a member of the Board.

A number of elected active and former scholarship holders of TUMJA represent the scholarship holders' voices. These representatives, together with active and emeritus professors, constitute a distinguished board of experts, who complement each other perfectly in terms of their diverse knowledge. Their different backgrounds and skills encourage and support the exploration of new organizational ideas. The strategic themes include in particular the purpose and direction of TUMJA as well as its interaction with TUM's

several institutions and their programs, such as the Global and Alumni Office, the Corporate Communications Center (CCC), the Legal Office, TUM ForTe or the TUM University Foundation. Such collaborations and interchanges encourage the development of a governance framework that enables sustainable growth of the Academy. The Advisory Board also discusses proposals from the Board of Members. In addition, the Advisory Board is responsible for key operational tasks, which include the selection of new scholarship holders or the definition of possible project topics from the wide variety of submitted project ideas. The work of the Advisory Board is thus designed not only to generate new creative ideas, but also to provide challenging intellectual influences that can only enhance the program of TUMJA.

#### Director:

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

Scholarship Representatives: Monica Déchène, Saskia Hutschenreiter, Dr. Matthias Lehner, Andrea Schittenhelm, Paul Sieber, Martin Zirngibl

#### **Professors:**

- Prof. Dr. med. Pascal Berberat, TUM School of Medicine
- Prof. Dr. Sonja Berensmeier,
- TUM Department of Mechanical Engineering 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



**Speakers:** Johann Ioannou-Nikolaides Stefan Lehner Rui Yee Loke

#### **Board of Members**

The Board of Members (BoM) is a platform within the TUM: Junge Akademie representing all scholarship holders. The BoM serves to direct open discussions and formulation of proposals. The BoM is open to individual scholarship holders and alumni of TUMJA who are interested in shaping the future of TUMJA and who want to be part of the self-sustaining ecosystem.

This year, the BoM took a step further to restructure several rounds of meetings to achieve three main goals:

- 1. Create an even more friendly and inclusive environment for all scholarship holders;
- Improve connections between members and build stronger collaborations across projects;
- 3. Be a conduit for ideas, problems, and concerns of TUMJA members and management;

In the periodic meetings, the representatives of each project group and taskforce provide updates about the status quo of their assignments, during which ideas and advice are shared to support one another. Apart from the common representatives, all active members and alumni are invited to join the meetings and contribute their experiences and suggestions. The meetings are intended to synchronize different groups and people to achieve a vibrant cooperation and synergy. With all opinions taken equally into account, the establishment of a strong community should ensure that TUMJA continues to flourish and becomes the best it can be.

Subsequently, the BoM bears the responsibility to elect six student representatives to the Advisory Board. Building on the strong connection between the BoM and the student representatives of the Advisory Board, each scholarship holder takes an active part in the decision-making process.

### **TUMJA Office**

The office staff of the TUM: Junge Akademie assist its scholarship holders in planning, organizing, implementing, and evaluating their projects and ideas. This support can be quite diverse. Where one team needs assistance with technology, another team might just need the right people to get in touch with. The office pays special attention to networking and joint cooperation between all members. Together with the Taskforce Event, unforgettable experiences are created, such as visits to museums, running dinners, or Christmas parties on the premises of the TUMJA. The teams are free to use the premises and offices of the TUMJA. This makes it easier to hold project team or taskforce meetings. The premises also invite you to spend some time together once the meetings are over.

The managing office, however, does not only take care of the concerns of the scholarship holders. The TUMJA management also serves as a point of contact to connect with other TUM-internal or external partners. It is always in close contact with its partners, such as the TUM Universitätsstiftung, the industrial partners Pixida and QuantCo, and the three partner universities in Munich. Some of the core tasks primarily include administrative and financial matters. The planning, coordination, and realization of major events also fall within the broad range of tasks of the office. Each year, the TUM: Junge Akademie hosts several extraordinary events: Academic talks, Fireside-Chats jointly organized with TUM Graduate School, the TUM Science Hackathon, or the annual TUM Campus Run. In 2022, the new format Wordshops evolved from the TUMJA Book Club, and in 2023, we are participating in Munich's Flower Power Festival.



## Faces

## Scholarship Holders 2022

#### Faces



#### Aastha **Chandiwala** SustainAct Electrical Engineering and Information Technology

(M.Sc.)

I am driven by the endless possibilities of science to innovate and create – delving deep into a problem, pushing boundaries, finding unique approaches, and satisfying my curiosity.



#### Ioan-Daniel **Crăciun** Aesthetics Informatics (Master)

My highlight at TUMJA was supervising the Science Hack with the other taskforce CAP members.

Nina **Dieminger** Aesthetics Molecular Biotechnology (B.Sc.)

The scholarship enables us to learn how other people from other studies have a look at different topics. This is not only very interesting but also extended my own look at different topics.



Sophia **Duggen** CheckMate Biochemistry

Through the TUMJA scholarship, I learned so much about how to carry out a team project: From finding a solid research question to coordinating work packages and communicating within the team.





Laura **Gentner** Membrains Mechanical Engineering (Master)

My best moment was realizing my teammates have the same idea of our work and the same sense of humor, which made our time intensive but especially full of fun.



Pia **Gutsmiedl** VINFO Medicine (MD)

For me, research means progress and mutual exchange. This is associated with interesting and challenging tasks. Working on these motivates me and lets me participate in research.



#### Til Hagendorn

CheckMate Management & Technology (B.Sc.)

TUMJA highlighted the importance of interdisciplinary teamwork and collaborative learning to tackle complex problems and achieve success via diverse skill sets.



Maximilian **Hampel** VINFO Molecular Biotechnology (M.Sc.)

I am a very curious person; research scratches that itch of gaining new knowledge about the world around (and inside) us.

Manfred Klemt CheckMate Politics & Technology (M.Sc.)

During the scholarship I was able to engage with very interesting people from academics but also from the business and politics realm. I also appreciated the Mentoring program a lot.



Katharina Küllmer CheckMate PhD in Life Sciences (Dr. rer. nat.)

The highlight for me was, networking with students from diverse programs, which is vital for growth, offering unique perspectives, interdisciplinary thinking, and lifelong connections.





Emilia Litzka Membrains Engineering Science (Bachelor)

My favorite memories are the many moments shared with my teammates during the seminar weekends. I feel very lucky to have met so many interesting and passionate people from all fields of study.



Tobias **Loferer** Membrains Medicine (State Exam)

My motivation is mainly to get objective results, which can be used to solve important problems. Since science always helped us in this regard, it is important to continue this approach.

#### Faces



Mohamed Zied **Jaber** Aesthetics Physics

The most important thing for me is to get better everyday and be the best version of myself. I hope to inspire those around me to be great at what they aspire to be.



Seong-Min **Jun** VINFO Information Systems

TUMJA broadened my horizon. I learnt so much valuable lessons that I hadn't received solely through my studies!

Sophia Maria Rebecca Leiß Aesthetics Health Science – prevention and health promotion (M. Sc.)

During my time at TUMJA, I met people from diverse backgrounds and, most importantly, my mentor!



Wenxuan Li CheckMate Information Systems (M.Sc.)

Seeing our experimental web application being used by test users for the first time was great.





Miguel Marcano Bethencourt CheckMate Informatics (B.Sc.)

Through TUMJA I've gotten the opportunity to participate in fantastic events and meet amazing and inspiring people that motivate me to give my best for my studies and future career.



Julius Maximilian Miers CheckMate Management and Technology

It is my passion to explore new horizons and discover the unknown that drives my academic motivation.



#### Cheng **Pan** VINFO Mechanical Engineering (Master)

My motivation: using science/ math/technology to describe/ explore the world and trying my best to solve some problems that can be helpful for people/ nature/world.



Valentin **Pauli** VINFO Physics

My best moment at TUMJA: When I realized how far we've come, from a thrown-together bunch of people full of ideas to a highly motivated collaborative team giving a talk at a conference in Copenhagen.

Moritz **Ptacek** SustainAct Sustainable Resource Economics (M.Sc. / PhD)

The best moment: Support from Peter even after the team literally broke up and the following second spirit.



Kathrin **Schmalzl** Aesthetics Sport and Exercise Science

The most exciting contact I made during my scholarship was with my mentor. I got to know him as a very inspiring, knowledgeable, and unique personality, and I appreciate him highly for his support.





Alexander **Sobieska** VINFO Politics & Technology

The scholarship was very important for my studies. We are going to present our project at the 9th International Conference on Computational Social Science in Copenhagen which will be my first conference.



Vinh Phuc **Tran** CheckMate Mathematics

Through TUMJA I have met many interesting and ambitious people who have inspired me over and over again. I especially value the contacts I have made within my team.

#### Faces



#### Matthias **Pixner**

Aesthetics Mechanical Engineering (M.Sc.) / Mechatronics and Robotics (M.Sc.)

The contact with scholarship recipients from diverse disciplines was immensely rewarding and undoubtedly the most enjoyable aspect of it all.



#### Lenz **Pracher** Membrains Physics (B.Sc.)

The TUMJA scholarship program has enabled me to get a working student position, improve my managing and research skills, and helped me to meet many great peers.

Lucas Schnack CheckMate Informatics

My motivation for science is the desire to push existing boundaries and always learn something truly new.



Christina **Schwalm** Aesthetics Architecture (M.A.)

It was great meeting all kinds of different students on the weekends and working on our projects. Also, the moment we all sat together and found out how our prosthetic could work.





Benjamin **Villard** Membrains Mechanical Engineering

The most exciting contacts I made during my scholarship were with some of the other scholarship holders, who became very good Friends of mine.



Constantin von Witzleben Membrains Engineering Science (B.Sc.)

The experience gained working on such a long-term research project besides my studies allows me to make informed decisions and better plan my potential future career in research.



#### Steffen Wedig CheckMate Materials Science

and Engineering (M.Sc.)

We spent months researching, planning, and developing our project. Finally seeing the pieces of it come together in the hands of our study participants was my best moment at the TUMJA.



Rosa J. Weidenspointner VINFO Biochemistry (M.Sc.)

Meeting my teammates and getting to know them was incredibly inspiring. After working hard on our project, we were approved for IC2S2. Interdisciplinary teams can accomplish unexpected challenges!

Julius Johannes Wenzler Membrains Management and Technology

Through TUMJA I got the unique opportunity to look into other fields and learn about necessaities of respective tasks. I leave with a much deeper understanding of science and research.



Corinna Marlene **Winkler** SustainAct Medicine (State Exam)

Science and research for me means not just passively observing but actively contributing to and shaping our future.



## Tutors

Veronika A. **Bauer** SustainAct

Supporting the Team Sustain-Act has been a great pleasure and a fascinating experience.





#### Rodrigo **de Rojas** SustainAct

Being a tutor of an exceptionally capable interdisciplinary group of students has been an extraordinary experience I'd always like to repeat.



Monica **Déchène** Aesthetics

As a former scholarship holder, I'm thrilled to share my knowledge and experience as a tutor for team Aesthetics, and committed to foster interdisciplinary collaboration among excellent students.



#### Jonas **Ruchti** CheckMate

It is vital to be aware of our biases, privileges, and social responsibility. An interdisciplinary view helps us stay clear of gatekeeping, needless reinvention, and ultimately harmful concepts.



#### Andrea **Schittenhelm** CheckMate

Talent mentoring programs like TUMJA are a fascinating place where, it seems, out-of-the-box thinking happens faster because they create an environment that allows for mistakes and makes you brave.

Paul **Sieber** VINFO

Use chances to leave your comfort zone while studying.



Dorina **Siebert** Aesthetics

Even though it may seem difficult to bring together members from different fields of study, it has allowed for full creativity and purposeful good teamwork through multiple perspectives and different strengths.





Junianna **Zatsarnaja** VINFO

Mentoring the team gave me possibility to take a very close look on the project work from an outsider perspective and rethink success factors of a teamwork.



Martin **Zirngibl** Membrains

The great thing about mentoring other students is to see how young minds are transforming and improve their skills.
# Supervisors



#### Prof. Dr. Sophie **Armanini** CheckMate

TUMJA brings together highly motivated students with different backgrounds but with a similar open, curious and enthusiastic mindset. It has been a privilege to support them in tackling challenging interdisciplinary problems.



#### Dr. Eleni **Georganta** VINFO

I am proud to have been a part of these young academics' journey and TUM: Junge Akademie and look forward to seeing their future accomplishments.

Faces



Prof. Dr. Anna **Keune** Aesthetics

Mentoring the team was a lot of fun because of the energy the team brought to our interactions with them.



#### Oliver Lieleg Membrains

It was very interesting to see how a group of students with quite different backgrounds organizes itself to tackle an interdisciplinary problem.

#### Prof. Dr. Tilman Michaeli CheckMate

In my research, I want to explain the digital world and its phenomena and empower everyone to actively and creatively participate in shaping it.



Gwillem **Mosedale** Membrains

My wish for the Membrains: whether you do it quietly or overtly, I hope that you keep setting ambitious goals, always.





Prof. Dr. Cristina **Piazza** Aesthetics

It was insightful to experience the value of bringing together perspectives from robotics with social sciences, including systematic qualitative inquiry and co-design, through the team's collaboration.



Dr. Kristina **Schick** VINFO

Don't stop asking questions!

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# Project Report **Aesthetics**

From day one, our team was united by one common goal: the opportunity to give people who have lost a finger phalanx a piece of their old life back. Losing a phalanx can be a life-changing experience. Our solution to this is to research and prototype accessible, appealing and simple prostheses.

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Team	Ioan-Daniel Craciun Nina Dieminger Mohamed Zied Jaber Sophia Leiß Matthias Pixner Kathrin Schmalzl Christina Schwalm
Tutors	Monica Déchène Dorina Siebert
Supervisors	Prof. Dr. Anna Keune Prof. Dr. Cristina Piazza

# Preface by the Supervisors Prof. Dr. Cristina Piazza and Prof. Dr. Anna Keune

Throughout the project, we had many opportunities to connect with the team and to exchange ideas for improving the quality of their work. As the project progressed, we provided input and comments on the team's research instruments, which were critical steps to establish a clear direction for the team's work. We were pleased to see that the team took our feedback into consideration and adjusted their approach, project goals, expectations, and timeline. This helped them outline a plan and keep track of their progress towards team goals.

For the whole project duration, we provided guidance, feedback, and support to the team. We were particularly impressed by the team's energy and creativity, as well as their dedication to working on such an impactful topic. We also had the opportunity to exchange ideas during lab visits to the laboratories of both professorships, which provided the team with a clear and in-depth overview of the supervisors' research activities.

Our interactions with the team were not limited to laboratory environments. For example, we had the opportunity to spend an afternoon at the Lenbachhaus Museum, where we toured an exhibition and spoke with the curator. Additionally, we supported the Junge Akademie Hackathon in which the project team participated, which helped to foster connections to other professionals in the field. These were great opportunities to foster more personal relationships with the team members, which helped to create a supportive and open team environment.

As the project approached its conclusion, we attended the presentation of one team member, who was invited to present the outcome of the team's Aesthetic project at the Seminar Series of the TUM Chair of Cognitive Systems. This was a great accomplishment for the team and we were impressed by the student's ability to communicate the impact and importance of the project to a diverse audience. We also commented on the team's final project report, which helped to ensure that their work was communicated effectively and accurately. We believe that providing feedback on different aspects of the project is an important element of the mentorship. It makes it possible to guide the team in developing the necessary skills for successful future careers.

As mentors, we also learned a lot about each other's research activities through this project. Our lab visits provided an opportunity to exchange knowledge and expertise, which we believe is a critical aspect of interdisciplinary mentorship. Our complementary expertise allowed us to provide more comprehensive guidance and support to the team, which in turn helped them to develop a more impactful and complete understanding of the problem.

Our experience supervising the team Aesthetics was incredibly rewarding and provided valuable insights for us as mentors. We are pleased to have guided the team in designing a solution for a real-world problem and with a strong societal impact. This experience contributed to creating the foundation for a strong synergy between the mentors, which will certainly lead to further collaborations.





#### **Supervisor insights**

## What does mentoring the team mean for your own research?

Mentoring the team was a lot of fun because of the energy the team brought to our interactions with them. We saw the team bring together different disciplinary perspectives toward designing, developing, and testing responsible and socially meaningful prosthesis technologies. It was insightful to experience the value of bringing together perspectives from robotics with social sciences, including systematic qualitative inquiry and co-design, through their collaboration.

#### What special experience from your studies/career would you like to share with the scholars?

We have had interdisciplinary team project experiences at the intersection of design, engineering, and social sciences throughout our academic careers. These experiences have contributed to understanding the potential for high-gain results and long-term human learning that collaborative projects across disciplines can have. These experiences can expand young people's sensibilities about the opportunities for societal advancement through responsible technology design long beyond one single project. Some of the unique skills the team gained from participating may only become apparent to the team much later. We wish all of the team members the verv best for their future endeavors.

# The human side of the project

#### Who we are

The members of our team come from diverse backgrounds: Architecture, Biochemistry, Engineering, Health and Sport Sciences, Informatics and Physics. At the beginning, we thought that this could hinder the effectiveness of our communications, but in the end it proved to be our biggest asset. The diversity of our backgrounds allowed us to treat every subject with a myriad of different approaches. Ultimately, we saw that we were able to tackle every aspect of our project gracefully, from the more technical-based tasks like researching the available literature, designing and printing prototypes, and simulating different designs, to creating art for the prosthesis and interacting with persons who had lost limbs.

#### Our mission

Our team was united by one general goal from the first day we met: the possibility of giving people who have suffered an amputation procedure a part of their old life back. Obviously, these surgical procedures result in lower degrees of freedom for their movement, but this can influence even the most minuscule day-to-day tasks we are accustomed to. For example, drinking a cup of tea or taking your dog for a walk in the park can be hugely influenced even by the loss of the tip of a finger. Our solution for these problems is the production of easily accessible and simple prosthetics.

#### "For the people, by the people"

In order to create a prosthesis that would serve the people that need it the most, we decided to get in contact with potential users. The search for participants for our survey was not an easy one: we started by creating online forms, then we tried contacting bigger organizations with agricultural or more technical profiles, but all these attempts proved unsuccessful. Happily, in the end we managed, through our own connections, to find persons who had suffered a finger amputation during their lives.

Below, we reproduce an interview we conducted during the research. Frau Müller is a 58-year-old woman working in the cleaning domain.\* Like any other person, she enjoys going abroad during her holidays, where she likes to read, especially crime novels. However, there is one aspect of her life that she is reminded of every single day.

# Frau Müller, could you please tell us what led to you losing your finger?

**Frau Müller:** Well, it was in '98, I was working at the time with a milling machine for a personal project, that, mind you, had 2000 rpms; at that speed you don't even feel it. Just a moment of inattention and ... the upper part of my index finger was gone. Sadly, they could not reattach it.

#### Even though I knew of the missing finger from the beginning, hearing it from you now, gives me a taste of the impact it can have on one's life. One of the first questions I'd like to ask is, do you have phantom pains?

Frau Müller: No, not any. Actually, never had one, now I come to think of it.

#### I see. You are not wearing any prosthesis. Why is that?

**Frau Müller:** At the time of the accident, I was not offered any. I suppose I got used to it the way it is now and ... did not think of ever getting one afterwards.

If you were to get, let's say, a state-of-the-art prosthesis. Would you prefer it to be a static or a mov... Frau Müller: A moving one. Yeah, a moving one.

#### What is the main argument, in favor of or against, you getting a prosthesis?

**Frau Müller:** Well, it's a question of habit, you know. Once you get used to something ... you know 25 years have already passed. It's been the normal for a quarter of a century.

#### Did you ever want to get a prosthesis?

**Frau Müller:** I'd say no. Again, one-finger prostheses were not that popular back in the day.

<sup>\*</sup> The persons we have interviewed have wished to protect their privacy so the interview we have presented is made in such a way that the personal data have been modified.

But if you were to wear one, what would be the first thing you would consider about the prosthesis? Frau Müller: Pfff... the price.

Say the functional aspects of the prosthesis are achieved. What about the aesthetics of the prosthesis. What aspect would you prefer? Would you like to have a technical model, that does not aim to replicate the looks of a biological finger, let's say a more technical look? Or would you rather have something that imitates the real aspect of the finger?

Frau Müller: The one close to the real one. I mean, the rest of them are still real.

Alright. What about the color then? Frau Müller: My skin's color.

Logically. What kind of material would you prefer? Metal, silicon or a rigid form of plastic? Frau Müller: I'd say silicone.

And if you had to choose only one. What would you choose between: functionality, comfort and mobility? Frau Müller: Functionality.

I'd think that that is the most important part when it comes to daily tasks. Frau Müller, would you be available to test one of our models? Frau Müller: Yes!

Well, that was the interview. Do you have any other suggestions for us? Frau Müller: No.

Frau Müller, we are really grateful that you took the time to talk to us. We hope we keep in touch.

#### Thoughts for future

Even though it was completed at the end of our journey in this big project, the interview phase brought to our attention an important detail: the human side of the project. Humans are complex creatures and, happily, diverse. This means that there will never be a one size fits all solution. Each person has a different type of injury, which requires a different type of approach. *Every generalization is wrong, including this one* (a quote which is usually attributed to Mark Twain) is one of the conclusions we have arrived at during our project.

Our experience on this project was a first for all of us. It showed us at first-hand the complexities of trying to combine scientific and technical solutions, which are inherently *cold* and exact, with humans, creatures defined by their complex feelings and emotions. We hope that we will be able to take this experience and make use of it in our future projects.

# Everyday impairments caused by the loss of a phalanx and remedy by a newly developed 3D-printed finger prosthesis

#### Abstract

In order to assist people with a partial hand amputation with a helpful prosthesis that is also aesthetically pleasing and affordable, the current study aims to make an initial contribution. Although research has revealed that partial hand amputation is relatively common in amputations, research literature in this area is relatively sparse compared to the literature on more proximal amputation levels. This qualitative case study examined the challenges and obstacles faced by people with a missing finger phalanx, the extent to which a loss of a finger phalanx affects their daily lives, and the extent to which wearing a prosthesis can help minimize or compensate for the identified challenges of a missing finger-length and pressure pain. Two affected individuals were interviewed about how their everyday practices and quality of life had changed compared to the time before they were missing a finger phalanx. After transcribing the interviews, a descriptive approach was used to identify the main challenges and barriers mentioned. Since the study participants were able to acquire some coping strategies, such as taking a different hand position while playing the guitar, many things were still possible, but wearing a suitable finger prosthesis can provide relief in many (everyday) situations and, thus, can contribute significantly to improving the quality of life of the wearer. These aspects are in need of clarification and should therefore be used as starting points for further research, as a significant reduction of the identified challenges might help affected individuals in the long run.

#### Background

Calling an amputation of fingers or hands (i.e., a partial hand amputation) a minor upper limb loss or minor amputation, as is sometimes done, trivializes the day-to-day functional and aesthetic problems faced by an affected person (Kim, Powell, et al., 2022). A loss of a finger can have terrible psychological issues and a drastic negative impact on an individual's life, especially if the loss of function results in the loss of a job (Gavrilova et al. 2010). Many people lose a finger. We need to do something to make life better for these people. About 3.6 million people in the United States will be affected by an amputation by 2050 (Ziegler-Graham, MacKenzie,

#### NUMBER OF YEARLY AMPUTATIONS BY FINGER



Figure 1: Number of yearly amputations by finger (Harris et al., 2018)

of different grip patterns used by the anatomical hand, the technological complexity of the prosthetic replacement, the durability and self-repairing capacity compared to the anatomical hand, and the restoration of sensation. As a result, many of the affected people need more than one prosthesis (Kim, Powell, et al., 2022). In addition, prosthetic devices also have a major role in the adaptation process to amputation (Kuret et al., 2019).

#### **Goals and Methods**

The purpose of the current study was to develop an in-depth understanding of the extent of the impact of a loss of a finger phalanx (LFP; including phalanx amputations and phalanx losses due to, e.g., unintentionally getting into a cutting machine), in everyday life from the perspective of affected individuals through a qualitative case design, as their perspective provides first-hand information. In addition, the extent to which prostheses help minimize or compensate for the challenges of everyday life was investigated. Therefore, the following research questions were developed: (1) What physical and psychological challenges do people with an LFP face compared to their life before and to what extent does the LFP affect their everyday life? (2) How and to what extent can a prosthesis help reduce or compensate for the challenges in daily life of a person with a missing finger phalanx?

Therefore, we developed different prototypes. The first prototype called Sputnik (Figure 2) was created for the first test purposes. Right from the start we observed 4 main factors crucial for our design: (1) Attachment to the finger, (2) Mobility, (3) Sensitivity, and (4) the type of material. Creating a prototype requires a fast, but also functional, method of manufacturing. The first prototype was further developed (Figure 2) and reprinted on the basis of the new findings from the test runs and the interviews with those affected. We were able to print some of the early models by using commercially available 3D printers, such as the TUM Maker Space facility in Garching. This not only allowed us to test implementations of the prosthesis quickly, but also to test the first type of personalization by printing with different filament colors.

A purposive sampling (Sparkes & Smith, 2013) was conducted according to the following inclusion criteria to control for confounding factors: persons affected by an LFP, aged 18 to 60 years, willing to participate in our interview about their individual situation. Initial contact with potential participants was made by phone to inquire about study participation. The potential participants received an information sheet, including the study procedure and purpose, but no further details to avoid bias. The participant agreed to the consent form, including rights and data handling. Both participants (N = 2) were female (mean age = 42.4 years) and one participant was missing the first phalanx of the right hand index finger and the other was missing the first phalanx of the left hand ring finger. All study materials were written in English and German to suit the language of the

#### PROTOTYPE 1 | Sputnik

Bending the finger stretches the tendon on the upper side. Through a connection with the fingertip on the underside, an actuation is generated.



#### PROTOTYPE 2 | Elektrischka

Bending of asymmetrical geometries causes a moment (deviation moment). This is utilised here by causing the bending of the finger to twist the thickened part of the prosthesis. The mutual closure of both parts creates an actuation.



#### PROTOTYPE 3 | Anna

The movement is caused by the same principle as in the first one, now adapting the design to now common MEX printers. This should lower the price per prosthesis and also make it available as an open source variant.



Figure 2: Prototype development

participants. To maintain anonymity, personal data were redacted unless relevant to the research questions.

A qualitative case study design was chosen because it allows for an in-depth understanding (Crowe et al., 2011) of the perspective of persons affected and, therefore, greater focus on the impact of the individual life situation of the respective participants. This design was particularly appropriate since persons affected are difficult to reach for research purposes, as they often do not want to show themselves. An online video-call was used to discuss with the participant the main guidelines of the interview before asking the relevant guestions. A general guestionnaire was used to collect background information about the study participants, such as demographics. An interview was conducted using a semi-structured interview guide with non-leading, open-ended questions. This approach focuses on the relevant issues through predefined main guestions and provides the flexibility to deviate in order to pursue a more detailed response (Gill et al., 2008). The questions are generally specific yet still remain open-ended. An example of such a guestion is: "What is more important to you? Functionality, mobility, or comfort? Why?"

The main outlines of the interview are as follows: (1) Identity and demographic, (2) prosthetic usage, (3) prosthetic preference, (4) prosthetic impact, and (5) suggestions. The data collection, including the questionnaire and the interview, took place in person between December 2022 and February 2023. This method was most appropriate for creating a comfortable atmosphere for the interviewee and clearly enabled both the interviewer and the interviewee to elaborate and explain their questions and answers directly. This format is also suitable for complex questions and allows for queries and clarifications. All participants opted to carry out the interviews online and anonymously. The interviewer also had an interview schedule in order to evenly distribute the time spent on single questions between participants. The interviews were recorded digitally and then reproduced in an edited transcription. The audio recordings and interview transcripts are only available to the researchers. A descriptive approach was taken to analyze the data and synthesize it with the literature. An inductive approach was used to analyze the data collected.

#### **Outcome and Discussion**

In the following, the information from the interview was analyzed in terms of the research questions -(1) what physical and psychological challenges do people with a loss of a finger phalanx face compared to their life before and to what extent does the loss of the finger phalanx affect their everyday life; and (2) how and to what extent can a prosthesis help reduce or compensate for the challenges in daily life of a person with a missing finger phalanx? – and then synthesized with the literature.

One study participant reported problems playing an instrument such as the guitar because the affected finger was not long enough to easily reach the guitar strings. This is an important factor for the study participant, as she is a music teacher by profession. According to Burger and colleagues (2007), in general, less than 50 percent of those affected were actually able to do the same job after a partial hand amputation as they did before the amputation. In addition, people who did not perform manual tasks at work were more easily able to keep the same employment after the amputation (Burger et al., 2007). This underlines how important fitting a finger prosthesis is, so that affected persons do not have to retrain and could thus avert a financial loss. In addition, the study participant mentioned pain when gripping the strings. Pressing on guitar strings causes pain at the distal end of the affected finger. The study participant has neither stump pain (i.e. the residual finger part) nor phantom pain in conditions without pressing against something. Schley and colleagues (2008) reported in their study that phantom sensations and phantom pain are often negative long-term effects of a missing finger (Schley et al., 2008).

Amputations alter the peripheral and central nervous system. This includes phantom limb sensations that cause the amputee to feel as if the missing phalanx is still present. This can be expressed by stabbing, throbbing or electric shock-like sensations up to a cramped or painful immobile sensation of the finger limb (Collins et al., 2018).

There are a number of study limitations for the current study. Due to the case study design (N = 2) and the individual requirements in life, the findings cannot be generalized beyond the context of the examined cases. Recall bias might have occurred because the participant reported experiences and feelings that dated back years. The researchers are not members of the study population and have little experience with it, which may have influenced their understanding of the research topic. In addition, it was not possible to pilot the interview questions in advance on a person comparable to the participant. The data generated by the interview is subject to

many biases and effects. Participants are therefore subject to the Hawthorne effect, as they are constantly reminded that they are missing a finger and/or have a prosthetic throughout the interview. The participants are overly conscious, thus affecting the quality of the data. It would have been helpful to study the reactions of people who came into contact with those who have lost a finger.

#### **Summary and Future Goals**

In conclusion, missing finger length and pressure pain were identified as challenges in the everyday life of affected people, which should be scientifically investigated in the future with sufficiently large study groups to determine whether these challenges exist for more affected people. Because the study participants were able to acquire some coping strategies over the course of their lives, many things were still possible, although sometimes in a limited way, but wearing a suitable finger prosthesis can provide relief in many (everyday) situations and thus contribute significantly to improving the quality of life. These aspects should be used as starting points for further research, as a significant reduction of the identified challenges might help several affected individuals in the long term.

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### Self-reflection

The most challenging part of our experience came at the beginning of the project when we tried to identify a suitable research question. Doing research with different kinds of databases and with people coming from different backgrounds, one might shift the focus only to that subject that is most relevant in their respective fields of study. After weeks of initial research, followed by weeks of refining the search, we came to the conclusion that we should not get lost in our purpose but should stick to the theme of our current TUMJA class of 2022. Hence, we followed the slogan "learning from nature" and named our project accordingly, "aesthetics." We did so because there are quite a lot of characteristics from the way insects (e.g. ants) move that we could adapt to a prosthesis whose goal – among others – was not to look like a real finger but which actually impresses with a futuristic, nature-based design.

One of our biggest strengths is the interdisciplinarity that makes up our team. We had to learn each other's academic "language" in order to fully function together. This resulted in a distribution of the tasks among all team members. Some of us were firmer on the development process of a prosthesis, others were wellversed in scientific reading and writing, while others were the best ones to turn to when it came to questions of design and of how presentable our ideas might actually look to the public.

Future steps will involve transitioning from prototyping to developing a high-end product. Since our interviewees have already asked to try out the present prototype version, we will be happy to provide them with these. Based on their experiences, further research needs to be conducted on their feedback and adaptation must be made accordingly. Besides following up the active development process, extensive marketing strategies must be undertaken. Lastly, in addition to achieving excellent quality and employing appropriate marketing skills, it will also be essential to be proactive with developing companies.

#### **Acknowledgments**

We would like to express a special thanks to our tutors, Moni and Dorina, who did not only give us input when asked but also

reached out to us when they stumbled across something outside of our TUMJA bubble. They have demonstrated their greatest support through both virtual and in-person meetings by providing us with information and soft skills but also a fair amount of freedom for creativity and self-initiatives.

In addition, we are deeply thankful for the professional support that we received through our supervisors, Prof Dr. Anna Keune and Prof. Dr. Christina Piazza, for sharing their academic knowledge in the field of prostheses and the current research of respective designs and materials. Moreover, they made us realize that we should not only focus on the development of a prosthesis to fill the research gaps and the market, but also to acknowledge and meet the needs of the specific target group. Thus, they equipped us with much more than their academic knowledge: how to develop a product based on the process of evidence-based research!

Furthermore, we had the honor of speaking to Prof. Gordon Cheng, who is a big player in the field of robotics. He helped us enormously in explaining the current situation on the market and advised us on our best options for our primary goal and on where best to lay our emphasis. Therefore, we offer out great appreciation to him.

Another big thank you goes to UnternehmerTUM-MakerSpace. Thanks to their team we were able to print our very first prototypes and even got the chance to get photographed in the making. Those photos were followed by an interview with Verena Meinecke from the Corporate Communication Center on behalf of TUMJA. Doing those photos and the interview made us even more aware of our purpose and gained us attention for this project outside of TUMJA.

We say a big thank you to the participants of our interviews, which were qualitatively designed and individualized. Without you, the quality of our report would only have been half as good as it is now. You did not only have an impact and a main role in our study, but you also raised our awareness in terms of amputa-



tions and the emotional experience that might be bound to that. Since recruiting our target group was not the easiest part of this program, we are forever grateful for Peter Finger, who – despite his various tasks as the managing head of TUMJA – provided us with information and resources that might be useful for our special purpose.

Lastly, we would like to say thank you so much to the whole team of TUMJA! It has been one amazing experience in the last 20 months – along with the individual studies at TUM. They guided us in the process of finding like-minded people, identifying common interests, developing the research question, and helped in understanding the importance of good scientific practice. This includes the fact that we are not only alumni of TUM but of TUMJA, which offers so many exciting possibilities, including staying on as active members in the scholarship program even after its official ending – whether that be as a mentor for the teams of the new TUMJA classes, or continuing work in the taskforces, or even as a one-on-one mentor later on in life when leaving university and passing on one's own experiences to another student.

All these people contributed to the decision that we want to continue with our work after the official ending of the TUMJA program. Stay tuned!



#### OUR GOAL

We are developing a fully customizable and attractive prosthesis that can be adapted to each and everyone's needs.

We are conviced that additively menufactured prostheses will replace conventional ones at some point. And that is why we opted for itt

#### A SMART PROSTHESIS

With additive manufacturing, we can produce customicable components in large quartities. We can provide pafert-specific autions to increase user-finerofineses and acceptance. Whether its highly complex geometries or weight-optimized parts, with additive manufacturing, everything can be built

These is a suble selection of materials given different types of plastices to nyndry and there are various perceivses available in the industry (such as basic extrusion or selective laser elitering). These disguess of heedom yield different component peoplemise. Assessing the results of our research on existing prottheses, we will develop our own functional prototypes.

We will create the prosthesis from a single component and make it individually adaptable. As of now, the focus to on parts made of an electomeno material (preferably manufactures) in PBP(LB> or MU). The first obstacle is therefore the limit of resolution of these processes. Adoitional kinematics
 Fine personalized structures
 Feduced number of parts

We classify the technologies we need for replicating a finger into 3 categories. We base our classification on the function each category must perform:

JOINTS: the prosthetic has to be able to bend, approximately as a normal fingler would do.

SUPPORT: The prosthetic must be "grounded" stilly, such that it supports the reaction force its surface is opposed to.

SENSORIAL: The design has to replicate the texture and feel of a mail finger. It should also sppear petty and well-favoured.

September October Normal sized prototype November December Paper January 2023 February March April May MEMBERS Monics Dechline, Dorins Sieber inspired by SOURCES

POSTER 1:

ЛЛ

February 2022

March

April

May

June

July

August

The idea of creating a new prosthesis was in our minds from the beginning. The initial idea came from our mechanical engineer and inspired all of us.

We soon developed the aim of creating a prosthesis, which will be customizable and will also have an aesthetic appearance. This prosthesis should be able to adapt to the individual needs of the user. Hence, the prosthesis should ease the daily life of anyone who has lost a finger.

First, we focused on the manufacturing methods and immediately decided that we wanted to create the prosthesis with additive manufacturing since this would allow us easily to make adaptions for different users.

Before we could start with the production of the first prototype, we had to define the requirements, which our prosthesis should fulfill. After a thorough literature search, we defined three categories of the technologies we wanted to use: joints, support and sensorial.

After we finished discussing our first thoughts and had a rough overview of what we wanted to do, we started to compile the initial timeline and structure plan.



#### RESEARCH PROPOSAL

Our primary goal is to find out to what extent amputations impact the everyday life of the patient and by which degree do prostheses help outbalance them.

The secondary goal is to measure how the annual number of amputations is distributed among the population based on: gender, age, nationality and professional background and their correlations.

#### FURTHER GOALS

#### Furthermore, we will look at the implications of the prosthesis on the environment of those affected and create a separate questionnaire for this. For the same reasons, no distinction will be made between the type of prosthesis and the origin of the trauma.

The background is to find out from which degree of similarity of the prosthesis to the natural human organ an unpleasant feeling arises in the viewers. This is done by indicating the viewers of different images with different degrees of similarity to the real system.

#### NUMBER OF YEARLY AMPUTATIONS BY FINGER

MEMBERS



Monica Déchène, Dorina Siebert SUPERVISORS Prof. Dr. Cristina Piazza, Prof. Dr. Anna Keune

#### CONSTRUCTION

Sending out Surveys Martisting Phase I 30th Aug 1st Nov Advertising 20th Nov Survey Evaluation Final Research Paper Tax Mar. 1st Mat Final Prototype Tat. May Presentation Marketing Phase III

TIME SCHEDULE

#### DIFFERENT PROTOTYPES: PROTOTYPE 1 | Sputnik



PROTOTYPE 2 | Elektrischka



PROTOTYPE 31 Anna MEX # on per proof-size and also make





ing our own prototype in the course of the project. For reasons of cost and good accessibility as well as future relevance, the production is carried out using additive manufacturing (MEX). Up to now, we identified 3 constructs along with their respective variables and the resulting relationships.

in order to become aware of difficulties arising

ЛШ

1) It is vital to define the need of improvement in existing prostheses based on attri-butes like the mean time to failure (MTTF) of different functional parts.

2) Defining the type of tasks that are mostly affected by the loss of the respective limb. where we make use of the Southampton Hand Assessment Procedure (SHAP) as a

3) Which kind of prosthesis causes the lowest psychological impact on the user his/her environment?

#### PROGRESS

Our investigations are divided into 3 categories with the first category being literature research.

Here we study the current state of art in prostheses and the research for technical solutions to already known problems. The second category is the creation of a survey with the Evasys system. This will allow us to get a better outlook of the needs of people that already use or are interested in using a prosthesis.

The last and most complex part is the creation of the prosthesis through additive manufacturing methods. The literature research and the survey will be done online while the development of prototypes will take place at the Makerspace in

inspired by



POSTER 2:

#### Our primary goal was to find out to what extent amputations impact the everyday life of the patient and to what degree a prosthesis might help to counterbalance that impact. Therefore, we developed a survey. Furthermore, we wanted to figure out to what extent the prosthesis might impact on the environment of users. We did another round of literature search on this topic and developed another survey for the environment.

Unfortunately, we had to admit that the target group of our survey is very specialized and, therefore, hard to reach. After a few weeks, we had to change our plans since we had a very low response to the survey. Thus, we changed the strategy and started to find personal contacts who had lost a finger and planned to do some interviews with them.

Nevertheless, we started to develop the first prototypes. First, we designed them on computer software. After we had finalized our first prototype, we used the Makerspace of TUM to print the first three prototypes named Sputnik, Elektrischka and Anna.

An adaptation of our time schedule was necessary since the low response to our survey slowed the workflow. However, we were able to develop a new time schedule, which should guarantee our final success. 



#### RESEARCH PROPOSAL

Our primary goal is to find out to what extent amputations impact the everyday life of the patient and by which degree do prostheases help outbalance them.

The secondary goal is to measure how the annual number of amputations is distributed among the population based on: gender, age, nationality and professional background and their correlations.

#### FURTHER GOALS

Furthermore, we will look at the implications of the prosthesis on the environment of those affected and interview all adopendent persons who have lost one finger. The goal is to find out what every day problems occur due to the loss of a finger and how a prosthesis can help to solve three problems. For the same reason, or distinction will be made between the type of prosthesis and the origin of the thumam.

The background is to find out at what level of similarity of the prosthesis to the natural human organ an urgeleasant feeling arises in the viewers. (This is done by showing the viewers different pictures with different degrees of similarity to the nail eystem.)

#### MEETING WITH THE EXPERT

We have had a meeting with Prof. Dr. Piazza, in order to solve some of our questions on the techrical side. We have gained a better overview of various subjects, such as:

 Material: we have considered only solid plastics until now, but the addition of silicone could facilitate the addition of tendons

 Kinematics: trade-off between the actuation and the no. of degrees of freedom vs. the complexity and the space required by the finger's actuation

 Attachment: how we could be able to safely and securely attach the prosthetic to the rest of the hand, e.g. through a specially designed glove

#### CONSTRUCTION

 tst December
 End of phase 1 of the interview

 15th February
 End of phase 2 & 3 of the interview

 1st March
 Final prototype

 15th Morch
 Final prototype

 1st Mary
 Presentation

#### INTERVIEWS

TIME SCHEDULE

The questionnaire we have published were not was successful as we have wished, that is why we had to change our strategy in order to gather more data. We divide the intennew phase in 3 phases:

1) Finding fitting persons 2) Conducting the interviews 3) Processing the results

We have found 4 persons from completely diffeent backgrounds. This supports our thesis that people from all walks of life may profit from our prosthesis. Their professions are plane teacher, undertaker, cook and a personer. Also the gender ratio is 50;50. Some of the interview will be conducted outled in person, while otherwith be conducted online, according to the disposability of the interviewees.

For the interviews we have prepared 3 different documents: a consent form, general question form (for statistical purposes) and a semistructured interviews, where we expect various and person-dependent answers.

#### PREPARING FOR THE FINAL PAPER

In order to prepare our scientific fundmentials for the paper, we have started in June this year to gather as much information as possible about various domains regarding prosthetics and amputations. Utell November this year we have discussed and compared our findings in every meeting. Hence, we already consider that we have a good bibliography for the find paper. In order to become aware of difficulties arising during construction and production, we are creat ing our own prototype in the course of the project

ing our own prototype in the course of the project. For reasons of cost and good inconsubility as well as future initiance, the production is carried out using additive manufacturing (MEX). Up to now, we identified 3 constructs along with their respective variables and the resulting relationation.

 It is vital to define the need of improvement in existing prostheses based on attributes like the mean time to failure (MTTF) of different functional parts.

2) Defining the type of tasks that are mostly affected by the loss of the respective limb, where we make use of the Southampton Hand Assessment Procedure (SHAP) as a metric.

3) Which kind of prosthesis causes the lowest psychological impact on the user his/her environment?

#### PROGRESS

Our research is divided into 3 categories, the first of which is literature research.

Here we explore the current state of the art in prostheses and the research for technical solutions to already known problems. The second category is interviewing people living

with the loss of a finger. This will give us a botter picture of the needs of people who already use or are interested on using a prosthese the seation of the posthesis using additive manufacturing methods. The list and most complex part is the creation of the prosthesis using additive manufacturing methods colls. The ilterature research and interviews will be conducted online, while the development of the profotypes will take place at the Makeerspace in Garchina.



ПП

POSTER 3:

The focus was put on interviewing individuals who have experienced a loss of a finger and are willing to talk about their needs. A consent form, demographic and general questions format, and a semi-structured interview were prepared.

Finally, we were able to find four people who have lost a finger and who work in different professions. This variety of backgrounds enables us to have a wider insight into how the loss of a finger impacts on different individuals and different circumstances. With the data from the interviews, we were able to summarize the impact of a prosthesis.

Nevertheless, we had to adapt our time schedule again since the scheduling with the interview partners was quite difficult.

Simultaneously, we started to prepare our final research paper and started to summarize our literature research.

With the data from the interviews, we were able to adapt the functionality and design of our prosthesis. We were working on the final prosthesis and made a started on its production.





- developing an aesthetic prosthesis for all

LIFE

THOUGHTS FOR FUTURE

The interview phase brought to our atten-

tion an important detail: the human side of

the project. Humans are complex creatures and, happily, diverse. This means that there

will never be one size fits all solution. Each

person has a different type of injury, which

requires a different type of approach. How-

ever, keeping standardisation at a minimum

allowed us to come up with potential solu-

tions. For example an individually printable

who has) a 3D printer can create themselves

This could make it easier to deal with the

and adjustable prosthesis that any person

that has access to for knows somebody

ЛЛ

#### **RESEARCH GOAL**

Our team was united by one general goal from the first day we met: the possibility to give people who suffered a finger amputation a part of their old life back. An amputation can be a lifealtering experience. Our solution for this is meanch and prototype developement of accessible, appealing and simple

#### RESEARCH - meeting with the expert

We had a meeting with Prof. Dr. Plazza (Healthcare and Rehabilitation Robotics) in order to solve some of our questions on the technical side. This way we were able to gain a better overview of various subjects,

#### such as: MATERIAL

At first we only considered solid plastic or metal, but the addition of silicone could facilitate the addition of tendons

#### KINEMATICS

Trade-off between the actuation and the number of degrees of freedom vs. the complexity and the space required by the finger's actuation

#### ATTACHMENT

How we could be able to safely and securely attach the prosthetic to the rest of the hand, e.g. through a specially designed glove or silicone bracelet

#### SENSITIVITY

We stayed away from complex sensor technology on purpose, as the prosthesis should be accessible and affordable for everybody. However, we learned that the residual limb at the amputation is often sensitive and should be padded accordingly



Bending the finger stretches the tendon on the upper side. Through a connection with the fingertip on the underside, an actuation is generated.



#### PROTOTYPE 2

Bending of asymmetrical geometries causes a moment (deviation moment) This is utilised here by causing the bending of the finger to twist the thickened part of the prosthesis. The mutual closure of both parts creates an actuation.



#### PROTOTYPE 3

The movement is caused by the same principle as in the first one, now adapting the design to now common MEX printers. This should lower the price per prosthesis





loss in positive way.

Burger, H., Manet, T. & Martinese, K. (2007), Parties have amposition and and Participation, 2007), 1077-1077, March 107, 1081(1998) Salinghon, F. & Hand and new W. & Mills, Proceedings of Additional and Country & Additional APP-Provalisation (Saling Social Mandrover, 2020). 1117-134. https://doi.org/10.1016/j. ers S. Salara, 6 & State, 5 H (SUS).



POSTER 4:

The emphasis was on evaluating the interviews with affected persons who have experienced the loss of a finger phalanx and are willing to talk about their needs.

First, the questionnaire on demographic and general questions was evaluated. Then, the semi-structured interviews were transcribed and gualitatively analyzed. Based on these results, we were able to summarize the impact of wearing or not wearing a prosthesis on daily life and well-being. Finally, the analyzed interview data were discussed in the context of the existing research literature on this research area.

With the data thus obtained, we were able to rethink the functionality and design of our prosthesis and incorporate it into the development of the final prosthesis.

It was very challenging because the study participants had very different backgrounds and had never worn a prosthesis before, but it also shows that we are going in the right direction with our research and there is still a lot of potential here.





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F A K E C T

# Project Report CheckMate

Today's digital world is filled with an abundant amount of information, both reliable and unreliable. With the rise of social media, it has become easier than ever for false information to spread quickly. As such, it has become increasingly important to be able to detect fake news when they encounter it. Fortunately, there are a number of strategies that can be used to help detect fake news, allowing to make more informed decisions. Our interactive tool aims at improving the capability of German high schoolers to detect fake news by confronting them with real and fake news.

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Tean	1	Sophia Duggen Til Hagendorn Manfred Klemt Katharina Küllmer Wenxuan Li Miguel Marcano Julius Miers Lucas Schnack Vinh Phuc Tran Steffen Wedig
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Supe	ervisors	Prof. Dr. Sophie Armanini Prof. Dr. rer. nat. Tilman Michaeli

# Preface by the Supervisors Prof. Dr. Sophie Armanini and Prof. Dr. Tilman Michaeli



We are honored to present Checkmate, a student project dedicated to promoting critical thinking and digital literacy. Thanks to the collaborative efforts of a highly motivated and multidisciplinary group of students, this project has made a valuable contribution to equipping young people with the tools to navigate the complex and often deceptive world of information.

Checkmate is a comprehensive initiative aimed at improving K-12 students' ability to identify fake news. At its core, the project recognizes that the proliferation of false information is a growing threat to our society and that it is increasingly important for individuals to separate fact from fiction. To this end, the team Checkmate has developed an innovative digital teaching tool that has been successfully tested in high schools across Bavaria. Through real-life examples and interactive exercises programmed into a custom-built app, students are encouraged to engage with news and media critically, identify markers of falsehood and deception in an interactive and intuitive way, and share their insights with their peers.

What makes this project truly outstanding is its emphasis on empowering young people to become active and informed citizens capable of confidently navigating the complex terrain of the modern media landscape. The project not only fosters the development of essential critical thinking skills but also promotes a sense of responsibility and engagement that is valuable in all areas of public life. At a time when misinformation and fake news are increasingly prevalent, it is vital that we promote digital literacy and critical thinking. This student project is a model for how we can equip the next generation with the skills and knowledge they need to navigate the complex world of information. We are honored to have mentored this talented group of students throughout their project and proud to showcase their accomplishments.

# Successful training for detecting fake news



Even small stimuli can help pupils better debunk misinformation

Even simple clues, such as paying attention to the source of fake news articles, lead to a significantly better ability to distinguish between correct and false information in the form of news articles.

This is the result of an educational intervention based on a self-developed web app conducted by the student research team Check-Mate of TUM: Junge Akademie. Pupils of grades 10 to 12 at three Munich high schools participated in November and December 2022. The aim was to increase the ability to detect fake news.

Furthermore, the study showed that even a short training period leads to first small improvements in fake news recognition among pupils. To achieve long-term and significant effects, larger scale initiatives would be essential in the combat against fake news and their propagation.

During the intervention of the TUM team, implemented in a 45-minute school lesson, pupils from Gymnasium Derksen, Gymnasium Kirchheim and the European School Munich were exposed to a web app containing a total of 24 articles retrieved from online portals of traditional newspapers and from social media. Among these were articles from online magazines such as "Rubikon" which frequently comments on political events in the form of conspiracy theories. The pupils were instructed to assess the veracity of the presented articles on a 5-graded scale from "fake" to "true" while being divided into two groups: The treatment group received immediate feedback on whether the rating was correct along with indications on typical characteristics of fake or real news articles after each question, whereas the control group moved on to the next article without feedback. Significant performance differences could be observed: For example, a truthful article about the use of a diabetes drug to lose weight was rated as "rather true" or "true" by 83 percent of the treatment group, compared with only 47 percent of the control group. However, such results were not observed for all questions.

#### Commentary

Even US-presidents have their own concept of truth and mass media. Former president Donald Trump for instance, when he stated: "Any negative polls are fake news, just like the CNN, ABC, NBC polls in the election. Sorry, people want border security and extreme vetting."

This is what Donald Trump tweeted on February 6, 2017 in response to the named media outlets' predictions regarding the preceding US presidential election he won against Hillary Clinton, the Democrat's candidate at that time.

Particularly interesting about this testimony to Trump's relationship with the truth, who back then was arguably one of the most powerful men on the planet, is how it underlines the fundamental issues related to fake news in our modern world: Anyone can distribute a piece of information around the entire globe within a matter of seconds. Once the enter-key is hit, there is hardly a way of stopping it. Making its way through a dense forest of statements and responses, of subjective opinions and objective propositions, of true statements and lies, the contained message, be it truthful or not, experiences an evolutionary process of multiplication, adaptation and alterations – this single Tweet alone has over 50 000 replies.

Next to its dynamic and the lack of external control, the multi-layered nature of today's media landscape adds a further lev el of complexity. Not only via social media, also via the "conventional" channels such as TV and newspapers, information is spread quicker and in larger quantities than ever before – making it easier to lose sight of what is true and what is not. Yet especially in digital formats, where a predominantly younger audience is targeted, the issue of fake news is very prominent. It is hence of major importance to educate and train adolescents in their handling of the information they are being addressed by.

A small, yet important step in this direction was recently made by the research initiative CheckMate, who successfully built and launched a digital training application educating German high schoolers on how to identify such fake news articles. Statistical analyses comparing the performance of the study's participants exposed to an educational treatment to that of a control group in their ability to discern false from true information indicates the training's potential to significantly improve detection rates. The next step must now be to increase the reach of the application and by making it available to a wider range of students in order to better equip the upcoming generation with the skills essential to survive in this modern jungle of information, where even some of our society's most impactful leaders may contribute to this crisis - for instance by disseminating false allegations about truthful outlets arguably disseminating false allegations. What an irony - too bad the topic is far too serious and the problems far too severe to be subject to a joke.

# A fake news competency training web app increased the misinformation detection skills of high school students

#### Abstract

The spread of misinformation over digital media influences public opinion and societal decision-making. Teenagers and adults in their twenties use digital media and encounter misinformation frequently. To address this challenge, we developed a scalable, webbased application that trains students in fake news detection by pointing out typical characteristics such as sources, graphic style, or writing style of such texts. In this work, we investigated whether this application improves high school students' misinformation detection abilities in nonfiction news articles compared to a control group. N = 104 participated in the intervention study. We found that if the students got feedback on typical characteristics of fake news articles, their ability to discern these from articles with accurate content increased significantly compared to the non-feedback control group (p = .0003). Our results confirmed that our application could be used in the future for training students' fake news detection capability.

#### Background

The dissemination of false and misleading information, often called "fake news," has become a significant concern in today's society. The use of social media and messenger apps accelerates the dissemination of misinformation articles compared to traditional news media (Feierabend et al., 2017). According to a study by Vosoughi and colleagues, fake news on Twitter spread six times faster than accurate information (Vosoughi et al., 2018). The consequences of this can be severe: Repeated exposure to fake news is known to increase belief in fake news (Pennycook et al., 2018). At the same time, trust in legitimate news sources is being undermined (Hasebrink et al., 2021). Trusting misinformation can lead to dangerous actions such as injecting oneself with bleach after it was proclaimed as a supposed cure in light of the COVID-19 pandemic (World Health Organization, 2020a) or the alleged targeted demobilization of Democratic voters in the 2016 US election by Russian trolls and bots which eroded trust in democratic institutions (Zeit Online, 2018).

Misinformation poses a significant risk to adolescents in particular, as they frequently use the internet as an information source. In Germany, 60 % of 16–25-year-olds agree that the internet is the best way to gather information, while only 25% rely on print media (comdirekt, 2019). However, during the use of digital media, they often encounter misinformation. 56 % of 12–19-year-olds said they had encountered fake news online (Feierabend et al., 2022). These circumstances necessitate the development of methods to prevent the adverse effects of fake news.

Two different approaches to limiting the spread of misinformation exist. First, misinformation can be addressed by social media platforms directly. Here, social media companies implement interventions on a content-level and on an account-level. The content-level intervention through automatic or manual moderation consists of flagging (i.e. adding a warning to content that is misleading) or deleting articles. Research on flagging has shown mixed results. While cognitive activity is increased by fake-news flags, confirmation bias prevents an impact on the user's judgment (Moravec et al., 2019). Other studies have found that flagging significantly reduces the believability and spreading of fake news (Ng et al., 2019). The account-level intervention consists of, for example, deleting the accounts that post misinformation. However, new accounts can be created by publishers.

The second approach to limit the spread of fake news works on an individual level by strengthening the individual response to misinformation seen online. Fact-checking websites provide additional information to enable consumers to evaluate the facticity of a shared news article. Alternatively, educational methods aim to strengthen critical media competencies (Lazer et al., 2018). One framework for educational intervention is the inoculation theory. The inoculation theory assumes that pre-existing attitudes determine a consumer's response to media. It proposes presenting a weakened version of misinformation and to point out relevant characteristics of misinformation. Individuals are taught to critically evaluate information and become more aware of counterarguments and of how to identify future pieces of misinformation. Two components are essential for a successful inoculation. First, a clear indication that misinformation is presented. Secondly, a clear explanation of the typical arguments and characteristics of misinformation (Cook et al., 2017).

Different methods of inoculation have been investigated in the literature. Brashier et al. evaluated how the timing of a "false" or "true" tag affected the assessment ability of fake news when rating the veracity of headlines of fake news in the long run. They found that providing fact-checks after the headline was classified the most effective (Brashier et al., 2021). In another intervention from Südwestrundfunk, people were taught to recognize and distinguish real and fake news. The website SWR Fakefinder asked users to classify online articles in a social media context as "fake," "true," or "satire." After the assessment, the correct answer was provided immediately (SWR Fakefinder, 2023). A study published by Roozenbeek and van der Linden developed a "fake news game" in which participants are asked to actively create news articles about the European refugee crisis using misleading tactics and from the perspective of different types of fake news producers. The results provide preliminary evidence that playing the fake news game reduces the perceived reliability and persuasiveness of fake news articles and suggest that educational games may be a promising tool to inoculate the public against fake news (Roozenbeek & van der Linden, 2018).

This work aims to develop and test a web app to be used as an intervention for high school students. The web app is designed after the principles of inoculation theory outlined above. We thereby transfer prior research results on inoculation theory into the classroom environment. There, the web app can be easily integrated into the standard educational structure of high school students. Media literacy is already part of the curriculum in German high schools (Kultusministerkonferenz, 2012). Therefore, we investigated to what extent our custom-developed web app improved the ability of German high schoolers to identify fake information alongside its distinctive characteristics. Moreover, our study gathers insights into the status quo of the fake news literacy of German high schoolers while aiming to reduce the impact of fake news on society by promoting a better-informed youth population.

#### Goals and Methods Research Rationale

This study aimed to measure and improve German high schoolers' fake news recognition capabilities in grades 10 through 12. We define fake news recognition capability as being able to correctly assess presented news articles and classify them as "fake" or "true." The proposed short-time intervention, focused on short-term learning processes, was based on the inoculation theory. We aimed to answer the following research question: "To what extent does our developed web app increase the capability of German high schoolers to identify fake information alongside its distinctive characteristics?"

#### **Study Design and Intervention**

The study was conducted in sessions which lasted 45 minutes. First, the relevance of fake news was briefly explained. The use of the developed web app constituted the second part of the session, which lasted 20 minutes. Students were introduced to the use of the web app and accessed it on their individual devices. First, they entered personal data including age, gender, weekly media consumption in hours, and a self-assessment of their fake news recognition capability on a five point likert scale of 1 (=unable to identify misinformation) to 5 (=certain to be able to identify misinformation). After entering the data, 24 news media articles were shown to the participants one by one (12 factual, 12 fake). All students saw the articles in the same, predefined order. They were then asked to grade each article on a 5-point scale, respectively (1 = "fake," 2 = "rather fake, " 3 = "do not know, " 4= "rather true," 5 = "true"). Students were assigned randomly into equally sized control and intervention groups per class. After each response, the intervention group received feedback on their answer. The control group was shown the next article directly. The feedback consisted of the solution to the question and feedback on two to three relevant cues to detect possible fake articles, e.g. picture sources, publisher information (or lack thereof), general appearance of the article and web site, characteristics of text, language, and writing style. Figure 1 shows the user interface during feedback. We asked participants to answer the questions independently of their peers. They were also unaware of the existence of a control and intervention group. At the end of the experimental session, fake news characteristics were discussed in an open discussion within each class.



#### Figure 1: Example of feedback the intervention group received after answering a question.

#### **Recruitment of High Schools**

The team CheckMate first contacted high schools and spoke with the school administrators of interested institutions. The study design, intervention, and research questions were explained, including the possible benefits for students. Finally, the teachers were asked to consider allowing the team to conduct the intervention with their students. Three high schools participated in the study, with two, three, and four classes (grades 10 to 12), respectively. This enabled comparisons of the students' capability to detect fake news between different grades within the same high school.

#### App development and data collection

The web-based application was developed using Python, and the Javascript framework React. The user interface was designed using Figma. The articles were collected as screen captures from social media, personal blogs, popular media outlets, the German-FakeNC database (Vogel et al., 2022), and fact-checking websites. The complete list of articles can be found in the supplementary material. The web app's performance was pilot tested with 20 TUMJA scholarship holders in advance. The user's response and the response time stamp were collected for every article presented. Data was collected and saved in a PostgreSQL database.

#### Data Analysis

Classes from grades 10-12 at three German high schools were visited, resulting in a total of N =104 participating students ( $n_{treatment} = 51$ ,  $n_{control} = 53$ ). The average age was 16.02 years (SD = 0.94). In total, 49 males ( $\approx 47\%$ ), 51 females ( $\approx 49\%$ ), and 2 diverse ( $\approx 2\%$ ) participants took part. The average weekly media consumption in hours was 11.45 (SD = 13.15), and the self-assessment of their fake news detection ability was, on average, 3.23 points (SD = 0.88) out of five. Fake news detection scores were calculated as follows (Equation 1).

Equation 1: Calculated score based on the student's answers.

real article = 
$$\frac{2 - score}{2}$$
 fake news article =  $\frac{-2 + score}{2}$ 

As a nonparametric test for ordinal data, a Mann-Whitney U test was performed, treating each question as an individual data point with the relevant group features (treatment or control) and score. For each of the tests, we set the significance level to 0.05. The score was determined on an ordinal scale ranging from -1 (wrong answer) to 1 (correct answer). Intermediate values of 0 and  $\pm 0.5$  were assigned for neutral answers and answers expressing uncertainty in their choice. In the following, the analysis is based on

questions 7 through 24 excluding question 18. As the participants were drawn from the same group, we expect them, on average, to perform equally before the intervention takes effect. We expect an initial learning period to be required before the treatment group can differentiate articles better than the control group. Therefore, we do not consider questions 1 through 6. Article 18 is an outlier, as the treatment group drastically underperforms compared to the control group (Intervention Group: -0.17 vs. Control Group: 0.23). We assume that this is a result of the design of previous interventions and is not related to the actual performance of the intervention group. This issue is further addressed in the discussion under "Difficult Articles." We therefore also exclude this article from our analysis.

#### **Outcomes and Discussion**

Overall, we can observe that our intervention significantly improves students' ability to recognize fake news (z = 3.25, p < 0.003, r = .078). We obtain a p-value of 0.003, showing that our findings are statistically significant, although a Pearson Correlation coefficient of only r = 0.078 indicates a very small effect. Figure 2 shows that the mean score of the intervention group is higher than the control group's mean score in eight out of nine of our experimental sessions.



Figure 2: Mean Fake News Detection score by class and experimental group.

#### Results

The mean score of the control group over all experimental sessions is M = 0.44, whereas identifying every article correctly corresponds to M = 1. The difference between actual score and perfect score highlights the relevance of raising fake news awareness and underlines the clear room for improvement in the students' capability to identify them.

For our intervention, we find that the intervention group performed significantly better than the control group with a p-value of 0.01 (medians: treatment = 1, control = 0.5, U = 398813.5, n\_treatment = 825, n\_control = 883, p < 0.01). In our case, it only take twelve solutions of fake news articles in combination with the feedback suffice to cause a small, yet not negligible effect (r = 0.093). This effect could be attributed to two causes. Firstly, it may stem from the difference that the intervention group receives the solution immediately after answering each article, compared to the control group, which receives the solutions at the end of the session. The positive impact of providing solutions immediately has been shown before and is associated with studying over extended periods of time (Biktimirov & Klassen, 2010). Secondly, the learning effect can originate from the intervention itself. We assume the intervention works immediately: The tool identifies typical characteristics of both articles with and without misinformation. Equipped with these characteristics held in short-term memory, intervention group participants can apply what they have learned so far when they are confronted with the same characteristics in similar texts during the following questions.

While the initial results are promising, the effect's strength is limited by the low number of training examples (i.e. articles and feedback) the students received and the short time they spent on the exercise in total. We presented only 24 articles in 20 minutes during a single session to the subjects. Presenting more articles and increasing the study time could improve the learning outcome. We suggest separating the exercise into multiple training sessions, as the task is reading intensive. It could be shown in past research that spaced practice increases the efficiency of learning (Kang, 2016). Therefore, we suggest a longer break in between exercise sessions (in the order of days/weeks).

#### **Differences in Mean Score between Experimental Sessions**

Figure 2 shows huge variations between the experimental sessions (SD = 0.060). We hypothesize two reasons for this. The first reason is demographic variation between the classes. For one, the classes that participated in our experiments are from three different high schools, so we expect that regional differences play a role. Furthermore, the classes also differ in their age structure, as they are from different school years. We found that age is an important parameter for fake news detection skills. Therefore, classes with different age structures are expected to obtain dif-

ferent results. Figure 3 shows the mean score across age groups ( $M_{age} = 16.0 \text{ SD}_{age} = 0.94$ ). We can see that the scores increase with age. This result can be explained by the greater experience which the older participants presumably have with navigating digital media. How this trend extrapolates to higher ages and other generations needs to be determined in future work. It is notable that in Figure 3, the values for participants aged 14 and 20 are uncertain and cannot be generalized, as there are only three and one participants in these age groups, respectively.



Figure 3: Average score stratified by age.

Nevertheless, differences persist even for classes from the same school and the same grade. A possible explanation for these differences could be the different classroom atmospheres we observed within the experimental sessions. In particular, the concentration of participants differed, as some classes read the articles more diligently and, therefore, needed more time to complete the task. Additionally, students in some classes were more willing to discuss articles and to share results with their seatmates. As these observations are subjective, it is necessary to establish an accurate metric for classroom atmosphere in order to reach a meaningful conclusion in future work.

#### **Characteristics of Low Scoring Articles**



Figure 4: Mean score of treatment and control groups for each article.

Figure 4 shows the mean score of the treatment and control groups across each article. The overall control group mean score of M = 0.44 does not accurately reflect the significant differences in apparent difficulty between questions. In the following section, we examine the commonalities of the five questions which had the most incorrect answers.

The first article, which shows a noticeably low score, was article 6. This article is an opinion piece in the German "Stern" magazine, which we rated as true. This text discusses and criticizes the public broadcasting licensing fee. The mandatory fee is a controversial topic in German public discourse, and it is frequently surrounded by misinformation. The critique commonly comes from groups on the political fringes. We hypothesize that the article is associated with misinformation sources solely based on the topic.

Articles 18, 19, and 21 are a group of articles which also show a lower score than the other articles. All articles share one commonality: They look like they are published by "Spiegel," a generally renowned German news magazine. "Spiegel" is considered to be trustworthy by 57% of Germans (Reuters, 2022). Questions 2 and 14 also feature articles that visually appear to be published by "Spiegel." However, in questions 2 and 18, we asked the participants to evaluate a spoofed article. Spoofing is a technique for deception, where the origin of an article or the publisher's identity is misrepresented (Innes et al., 2019). Malicious actors recreate the visual look, e.g., a "Spiegel" website, and publish misleading content, leading readers to believe that they are consuming media from the actual magazine. The spoofed articles posed a challenge for participants to identify and made them overall uncertain about articles bearing the Spiegel appearance, whether authentic or fake. This uncertainty indicates that spoofed articles can negatively impact the reputation and trust of a publisher.

Question 18 is noteworthy due to the large mean score difference between control and intervention group (Control Group: 0.096. Intervention Group: -0.229). We suppose that this difference is caused by the design of the feedback. In articles prior to 18, the intervention group had been taught to use information about the publisher to judge an article's credibility. As "Spiegel" is deemed a reliable source, the spoofed article misled the intervention group participants, while the control group students were not misguided by prior interventions. We therefore removed article 18 from the statistical analysis, as the poor performance was caused by the design of the experiment rather than the actual fake news detection ability of the intervention group. Overall, we conclude that spoofed articles pose a significant challenge to appropriate interpretation and can damage a publisher's reputation.

The remaining article that posed a challenge to participants is number 22. This article covers conspiracy theories, which appeared surrounding the Brazilian presidential election in 2022 claiming voter fraud. The article also establishes a connection to supposed election fraud in the US 2020 presidential election, peddling conspiracy theories further. Therefore, we rated this article as fake. Some participants implied that the article wanted solely to report on conspiracies but not to mislead. This shows that it is possible to promote conspiracies by creating the appearance of a legitimate report.

#### **Development of Answering Time**

We observed that the mean score of both groups is lower for the last six questions than the previous ones. It is unclear if this is only related to the articles' difficulty or to the experimental design. Furthermore, we observed that the average reading time varies greatly between articles. Our data shows a clear trend of the average time spent on reading the articles decreasing over the progress of our experiment, which can be seen in Figure 5.



Figure 5: Average reading time for each article over the course of the experimental sessions.

Multiple explanations exist: First, one explanation could be that participants identify fake news more quickly. Based on this assumption, we expect later articles to pose less of a challenge to the participants. However, we rule out this explanation as we still see an imperfect score. Secondly, the students getting used to the user interface could explain part of the decline in reading time. However, given the simplicity of the task and user interface, we deem this hypothesis insufficient for explaining the extent of the effect as well the prolonged decline in reading time after the first questions. Thirdly, we hypothesize that the students rush towards the end of the experimental session as we provide a fixed time frame for answering the questions. Time pressure could have led the students to spend less time on reading the articles in order to complete the whole experiment in time. Lastly, diminishing concentration and loss of interest could be the most prominent factor. We assume that the high number of articles as well as the repetitive task structure may have been detrimental to the students' interest towards the end of the experiment. While the exact causes and correlations remain unclear, we hypothesize that the learning outcome could be improved by splitting the experiment into multiple sessions and including short breaks, as suggested in the literature (McGinley, 2011).

One of the main limitations of our work was objectively evaluating the participants' performance. The score for a single question is a value from an ordinal scale (-1 to 1), with a lower score for uncertain or wrong answers. However, the score does not account for the varying levels of difficulty of the questions, as every answer is treated with equal weight. Furthermore, the score method does not account for degrees of uncertainty, when a student answers with the option "rather fake," "don't know," or "rather true." However, we settled with our score calculation method, as it is a simple and intuitive metric. It would be interesting for future work to incorporate different levels of difficulty, or a subjective rating of the difficulty of articles into the scoring method.

#### **Summary and Future Goals**

The spread of fake news is becoming an ever-growing problem in our society. In this work, we developed a training web app to strengthen users' fake news detection ability. The application consists of a web application, which presents participants with real and fake articles and asks them to determine their veracity. We conducted an experiment with an intervention and a control group among N = 104 German high school students in grades 10 to 12 during a regular 45 minute school lesson. The experiment itself lasted 20 minutes. The treatment group received feedback cues (e.g., source, reputation of news magazine, etc.) after each article. In contrast, the control group moved on to the following article without feedback. Our analysis showed that our web app significantly improved the feedback group's ability to recognize false articles even within such a short amount of time (p < 0.003, r = .078). Therefore, we conclude that our intervention, which was based on inoculation theory, is valid for using fake news training in the context of high school education.

Based on our results, we find three areas for further work.

- 1. Conducting tests with treatment and control groups regularly The training could be performed regularly (e.g., bi-monthly). Subsequently, we could analyze whether providing feedback for a larger number of articles leads to a long-term improvement in the treatment group. Tests with the control group should be conducted with the same frequency. Firstly, we can inspect if the control group might improve itself with self-learning. Despite not having constant feedback after answering each question, we presume that the control group's capability or awareness for identifying fake information can still improve by constant reflection during the use of our developed application. Moreover, the collection of time-series data from both groups would further enable evaluation of the app's efficiency.
- 2. Adapting our custom-developed application for experiments with different target groups

We could also examine our web app's effectiveness with other target groups. Since the scope of our research is limited to high schoolers in grades 10 to 12 in the area around Munich, we could adjust many variables for future target groups. For instance, we could conduct similar research with younger German high schoolers from different grades or those attending schools in other regions of Germany. Comparative research with senior citizens as the target group could also be profoundly insightful. However, here we would need to further develop our web app to adapt to changes due to the vast difference between the news-consuming methods of the younger and older generation.

3. Improving the feedback cues

With these first insights into the efficiency of our web app, we can start to optimize the intervention by varying different parameters. Here one could investigate the impact of changing the number of articles in a session, changing the number of the feedback items, or further elaborating on the characteristics of fake news mentioned in the feedback.

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## Self-reflection



Our Team CheckMate is an interdisciplinary team of 10 students who decided on a project focused on Fake News detection among high school students. We developed a web-based tool and visited high schools in Munich to share our tool with the target audience. This project provided us team members with a valuable opportunity to utilize our diverse skillsets and work together towards a common goal.

One of the strengths of this project was the team's commitment to meeting regularly and discussing next steps. This ensured that everyone was on the same page and contributed to a positive dynamic within the team. However, the team did face some challenges with coordinating the work, especially when team members were abroad or had other commitments. This led to delays and lower quality work at times.

Despite these challenges, we successfully completed the project and were able to promote our tool to high school students in Munich. This not only demonstrated our technical skills but also the ability to effectively communicate and promote our tool to a wider audience.

Overall, the CheckMate project was a valuable learning experience for all team members. We developed skills in teamwork, communication, and problem-solving, which will be useful in our future endeavors. Additionally, we learned how to overcome challenges and adapt to changing circumstances, which is an important skill in any professional setting.

With respect to how the project affected us, the students working on team CheckMate, a major aspect certainly is how it made us ourselves more aware of the dangers associated with fake news. While we were obviously all aware of the issue's general existence, its urgency did surprise most of us. For instance, while collecting the fake news articles to display while presenting the App at the schools, each one of us got a second view of how broadly fake news is distributed via the internet nowadays.

In addition to increasing our knowledge in the area of fake news, we all also benefited from the interaction with all the different stakeholders involved with the project. Be it the school directors and teachers we got in touch with to organize the sessions at the schools or the students themselves – working with people from diverse backgrounds did enrich our skillset in many ways such as finding an adequate communication strategy in interacting with important decision makers to figuring out how to convey a complex message to a younger audience.

Moreover, given the broad scope of the CheckMate App and the long process associated with its development, we also got a lot more experienced in project management. This for instance concerns how to define work packages in a reasonable manner, how to set up alignment meetings in a structured manner and how to come to decisions in a structured way. Overall, each one of us did really take a lot from the time at TUMJA working on the CheckMate project.



CheckMate

# Check 🖓 Mate

#### INTRODUCTION:

Smartphone, computer, Internet access and TV set – almost 100% of all households in Germany are equipped with digital media devices. As a result, children and young people have daily contact with these devices. Media consumption is a natural part of their everyday lives as they discover their world with and through media\*. This discovery is overshadowed by false and misleading information which is becoming more prominent. In Germany, there are six interactions with false news for every real news post on Facebook\*. Many young people have limited knowledge about the functions and working methods of journalism\*. School as an educational institution has the function of imparting to children a large part of the knowledge they need for life in society. According, writing and arithmetic, but also the new cultural technique of media literay\*.



PROJECT GOAL: Develop an interactive tool: >> that indicates whether one is able to distinguish fake news from real information, based on the answers of the person conducting the test >> that is tailored to information and fake news from the area of social media >> that increases media literacy of high-school students

>> that increases media literacy of high-school students in a playful way and encourage critical thinking when consuming information on social media



PROJECT PLAN:





POSTER 1:

πп

Well over half a year after our research group came together, we were finally able to agree on a research area where we saw the potential for a significant impact: Media literacy among high school students.

Did you know that the occurrence of Fake News is increasing? Today, there are already six interactions with Fake News for every reliable post on Facebook. This is a danger considering that in today's world, more and more young people are forming their opinions by consuming social media.

While at the beginning we had planned to explore the phenomenon of swarm intelligence in more detail and accordingly went by the project name "Swarmified," we had then made the plan to explore the phenomenon of fake news in more detail and to strengthen high school students in recognizing fake news. Project CheckMate was born.

We started with the definition of a project goal. In order to strengthen the recognition of fake news by high school students, we wanted to create an interactive tool that indicates whether one is able to distinguish fake news from real information, based on the person conducting the test, with the effect of increasing media literacy and encouraging critical thinking when consuming information on social media. For the execution of our research project, we accordingly set up a project plan and a corresponding timeline. The big milestone would be our school visits and testing of our tool at the turn of 2022. The focus in the second half of the year was therefore on developing the planned tool and finding suitable partner schools.
## пп Check **Mate** INTERIM RESULTS AFTER YEAR ONE - DEVELOPMENT OF A DIGITAL RESEARCH TOOL TO EVALUATE STUDENTS ABILITY TO DETECT FAKE NEWS **RESEARCH QUESTION:** To what extent does our developed tool increase the capability of German high schoolers and adolescents to identify fake information alongside differentialing characteristics/qualifiers PROGRESS UPDATE Since the last seminar weekend, progress has been made in regard to: Sol His 1. the development of our digital research tool. The first design mock-up and software prototype were developed and are presented below. 2, the acquisition of study participants. So far, we were able to recruit two schools. After finishing the software development, we are going to reboot our efforts to increase our sample size. 3. contacting the Bayrisches Kultusministerium to explore

- the legal cornerstones of data-sensitive research related to high-school students.
- 4. finding a second supervisor in Prof. Tillmann Michaeli, Prof. for Didaktik der Informatik.

#### METHODOLOGY

To answer our research question, we study German public and private high schools and confront students from grade 10-12 with realistic fake news according to the "inoculation method" presented in literature1. An approx. 45-minute-long lesson contains a short motivation of fake-news detection competencies, after which the students separately work on the tool. They are presented with articles, which may be credible or not credible (i.e., Fake News). The students are tasked to detect Fake News articles and assess the reliability of articles presented to them.

Denk Mate

They are randomly assigned to two groups. In the treatment group, the students receive not only the correct answer but also an indication of why an article may be a piece of fake news or not. The control group only receives information on whether their answer is correct. We evaluate the accuracy of their classification, its development over time played, and the relation to subject characteristics. The use of the tool is the focus of the lesson. After 25-30 minutes of work, the lesson finishes with a discussion of typical fake news literary and stylistic elements which were recognized by the students.



POSTER 2:

At the weekend seminar at the Starnberger See, it was time to draw an interim conclusion one year after the start of our cohort. After many iterations on the topic of strengthening media literacy among high school students, we finally agreed on the following research question: "To what extent does our developed tool increase the capability of German high schoolers and adolescents to identify fake information alongside differentiating characteristics/qualifiers?"

We had been progressing as planned in our set schedule to answer this research question and achieve our project goal of increasing the capability of Fake News recognition among high school students: on the one hand, we had developed a first design for our mockup as well as a first prototype. On the other hand, we were already able to convince two schools to test our tool. The biggest challenge in acquiring schools for our project was data protection regulations, since we would primarily be processing data from minors. For this, we read deeply into the topic of data protection and also brought Prof. Dr. Tilmann Michaeli, our second supervisor besides Prof. Dr. Sophie F. Armanini, into the team, who supported us with his expertise in the field of didactics and the methodology of our experiment.

It now remained to finalize the last developments on the tool and its design after previous test runs as well as to precisely plan the implementation of the test of our tool on site at the schools. 

## тлп

POSTER 3:

our web app.

Check / Mate

### A STUDY ON THE EFFECTS OF AN INTERACTIVE TOOL DESIGNED TO TRAIN HIGH SCHOOLERS TO IDENTIFY FAKE NEWS

Ownik -Mate

#### ABSTRACT:

Today's digital world is filled with an abundant amount of information, both reliable and unreliable. As such, it has become increasingly important for high schoolers to be able to detect fake news when they encounter it. With the rise of social media, it has become easier than ever for false information to spread quickly, and this can lead to dangerous consequences. Thus, having the ability to identify fake news is essential for the safety and well-being of high schoolers. Fortunately, there are a number of strategies that can be used to help high schoolers detect fake news, allowing them to make more informed decisions.

Our interactive tool aims at improving the capability of German high schoolers to detect fake news by confronting them with real and fake news.



After weeks of further developing the software for the web app, collecting fake news articles and annotating these with interventions, we were finally ready for a larger test just before the Seminar weekend at the Ammersee. There, the new scholarship holders of class 23 kindly tested our web app, gave important suggestions for improvement and validated our data collection. We incorporated the feedback and added the final touches to

At the same time, we planned our school visits. We developed a tripartite lesson structure with an introduction, an experiment and a discussion. We also met with high school teachers to discuss our class visits, explained our research idea to them and answered any questions from their side. After that, everything was set for our experiments. In November and December of 2022, we had four school visits, and 104 students participated in our research project. It was great to conduct the experiment sessions and see so many students using the web app. Many students were very excited about using a digital tool in the classroom and had a lively discussion with us about fake news items and how to discern them online.

With all the data collected, we eagerly anticipated the evaluation of our results. At the Schliersbergalm seminar weekend, we were able to present our first three takeaways and preliminary results. The first results mainly established the relationship between the personal data we collected from students and their score. Only later on were we able to evaluate the impact of the treatment on the ability to differentiate fake news.

## Check Mate

### A STUDY ON THE EFFECTS OF AN INTERACTIVE TOOL DESIGNED TO TRAIN HIGH SCHOOLERS TO IDENTIFY FAKE NEWS

**RESEARCH LIFE CYCLE:** 

#### SUMMARY:

The "CheckMate" team tackles the issue of young people encountering Fake News on digital media, impacting opinions and decisions. To tackle this challenge, they developed a scalable web app that trains students to detect Fake News by highlighting key characteristics like sources, graphics, and writing style. In this work, they investigated whether this application improves high school students' misinformation detection abilities in nonficion news articles compared to a control group. A study of 104 high school students found that those who received feedback on the characteristics of fake news were significantly better able to distinguish fake news from accurate articles (p = .0003). These results confirm the potential of the app to train students to recognize Fake News.

#### **RESULTS:**

1. Treatment group significantly outperforms control group



Having visited eight different high school classes Another interesting fact we found out we tested whether our web app improves is that older students were better at students' capability to identify fake news. The distinguishing between fake news and diagram above shows our results whereby we real news than younger ones calculated the score based on a metric we presumably because older students designed ourselves (worst possible score: -1, are more experienced in navigating best possible score: 1). In every class the digital media. treatment group having received feedback from our tool clearly outperformed the control group had not received any feedback from our tool.

#### SUSTAINABILITY IMPACT:

During four school visits in November and December 2022, Ieam "CheckMate" informed more than 100 students about fake dangers and characteristics of fake news. By letting them use a specially developed tool, the students could learn about fake news in an interactive tun way with an additional informational wrap-up and room for questions afterward. Although the students were able to significantly improve their fake news detection ability in the short time span of the sessions, there may be numerous possibilities to improve on the previous results. For example, repeating the training over longer periods of time could be a promising approach to making a lasting impact. Overall, recognizing fake news is a crucial skill in the modern world, and developing new ways to improve it will be necessary to arm our society against the ever-growing dangers of fake news.

2. Older students vs. younger

students

#### ACKNOWLEDGMENTS + PROJECT PARTNERS:

· Participating High Schools in Munich

Johannes Assum, TUMJA Alumnus

Technische Unversität München TUM Junge Akademie Glass 2022 TI Marthe Kleis Sophie Dugg MAY 2023 Waterins KM

Lucas Schnack Julius Miers Veih Phuc Tran Steffen Wedg Tuters Andrea Schitterheim Jonas Rucht Supervisions Prof. Dr. Sophie Armaniei Prof. Dr. ser. nat. Tenarin Michae



3. What can we improve?

We observed that the time students

spent on average per question

decreased over time. We hypothesize

this is due to students' concentration

diminishing over time. We think that

the learning outcome could be

improved by splitting the experiment

into multiple sessions.

## POSTER 4:

пп

After our trip to the Schliersbergalm, we continued evaluating our results by looking at the impact of the treatment. For each class we visited, we worked out the development of fake news detection ability over the course of our classroom session. There, we found that the intervention group improved progressively compared to the control group. Our idea and intervention worked! Furthermore, we looked at characteristics that were shared by the most difficult to detect articles. For all the results, be sure to check out the scientific part of our report.

After gathering all the results, we began writing our report. We split our text into chapters, which we first worked on individually. In our meetings, we collected feedback on each chapter and iteratively improved our scientific report. Our tutors and supervisors were a huge help in creating the report as well. They gave feedback on our style and content and provided new input.

During the final part of the project, we prepared for the presentation at the symposium. At the seminar weekend in Dachau, we developed the first rough sketch of our talk, and participated in workshops on rhetorical and presentational skills. In the following weeks, we finalized the presentation and wrapped up our project and time at TUMJA.



## Project Report Membrains

For the last decades, a dramatic increase of microplastic in the environment has taken place. To find a solution we investigated the suitability of a Manta Ray-inspired, non-clogging water filter to combat the worsening issue of microplastic water pollution. The Manta Ray is a source of inspiration as it can efficiently filter plankton from seawater to feed itself without its gills clogging. We examined the ability of the gills to create the so-called ricochet effect. This effect is created by the anatomy of the gills, which creates turbulent water swirls that make particles bounce off the gills while water can pass in between.

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Tutor	Martin Zirngibl
Supervisors	Prof. Dr. Oliver Lieleg Gwillem Mosedale

## Preface by the Supervisor

Prof. Dr. Oliver Lieleg



Even though our society has realized that the immense amounts of plastic we produce and dispose of are not sustainable, we are still way behind in creating solutions that might help us to deal with the existing plastic materials and the waste they create. These, however, do not only create severe problems for nature (be it in landfills or in the oceans): when broken down into microplastic particles, such plas-

tic waste can make its way back to us humans via the food chain. Indeed, there is increasing evidence that several medical conditions such as disorders of the gastrointestinal system, cardi-

## ovascular problems and neurodegenerative diseases are linked to an exposure to microplastic particles. Thus, this realization should strongly increase our motivation to avoid unsustainable plastic materials in the future, to quickly find solutions to avoid microplastic formation, and to prevent such microplastic from entering our water supplies.

The Membrains team decided to tackle the third item from this urgent to-do list. Inspired by the water filtration system of Manta rays, they designed a filtration unit that – according to the simulations conducted so far – should be very efficient in removing particulate contaminations from water. If experimental verifications of the designed prototype are equally promising as the simulation results obtained by the team, such a device could be extremely helpful in filtering out microplastic particles from processed water generated in industrial or private settings (e.g., after the laundry of clothes made from synthetic fibers).

### **Supervisor insights**

Having met several times with the Membrains team during the last year, it was very interesting to see how a group of students with quite different backgrounds organizes itself to tackle an interdisciplinary problem. The Membrains team soon realized that pursuing their very ambitious plan to design and craft a functional prototype within a year would be more complex and time-consuming than they had initially thought – but this is absolutely normal in the life of a scientist.

### What is your research interest or motivation for science?

In my own research, I investigate mucin glycoproteins, which are the key macromolecular components of mucosal systems such as the tear fluid, saliva, or gastrointestinal mucus. Recently, motivated by a touristic visit to India I made in fall 2019, we investigated how particulate air pollutants such as black carbon particles affect the barrier properties of mucosal gels – and we indeed observed significant alterations. Similar to those airborne particles, microplastic particles are also likely to have a negative effect on those mucosal systems. This is troubling as our mucosal layers constitute our body's first line of defense against pathogenic invaders, and messing with this defense line is a very bad idea. We are currently also looking into the question of how problematic microplastic particles are in this context.

## What special experience from your studies/career would you like to share with the scholars?

Both in my time as a PhD student and postdoc and now, leading a team of PhD students, the research work I was and am involved in was and is always conducted by people with varied scientific backgrounds. This makes daily research life a bit more challenging since – at least at the beginning of a project – all team members need to find a similar terminology when discussing their ideas. After a while, however, such a mixed team can achieve much more than more homogeneous groups. Looking at a scientific problem from different points of view is, in my experience, always helpful.

## Preface by the Supervisor

Gwillem Mosedale



We've all seen a pebble ricocheting across a lake. Each bounce giving rise to concentric ripples that expand and overlap. Eyecatching, but frivolous?

Not so! Ricochet separation is the basis for sophisticated filter designs. It took the manta ray and team Membrains to remind us that biology relies more heavily on filters than we do and that, therefore, it may have

a trick or two up its sleeve when it comes to showing us how to remove microplastic from pipes and waterways.

My lasting impression of this group is its demeanor: attentive, gracious, barely flinching when parts of the briefings got shaky because the responsible team member had another engagement. Combine that with an unassuming, calm assurance when meeting us supervisors or TUM's president and you have the Membrains.

My professional perspective is that of propagating a bioinspired approach across an organization, which has been my role at TUM. So, collaborating with TUMJA as part of the call "Learning from nature" was a good fit. Inevitably, I noticed some benefits that learning from nature offers: TUMJA participants cherish the freedom to work on topics of their own choosing. In addition to granting that freedom, the TUMJA leadership would like projects to acquire scientific relevance/publication quality. But unbridled freedom can lead to great projects that remain scientifically superficial. On the other hand, scientific work carries a degree of complexity which implies closer supervision.

Biomimetics, the study and transfer of (technical) solutions from biology to products and processes, satisfies both these aspirations. Teams are guided by natural models and less through external interference. A great way to grant freedom and foster science at the same time. The name is BIOMIMETICS ;-)

My wish for the Membrains: whether you do it quietly or overtly, I hope that you keep setting ambitious goals, always. There is more to be learned and achieved by aiming too high, initially, than the other way around. If biological evolution teaches us one thing, it's that our best chance at disruptive innovation lies in ignoring limitations (real or imagined) when we start out.

## The mysterious giants of the seas and the lessons they can teach us

In Greek mythology, Nausicaä, daughter of King Alcinous and Queen Arete, is a princess of the Phaeacians, people of sailors. In the sixth book of Homer's Odyssey, Nausicaä and her maids play by the seashore when they meet the shipwrecked Odysseus.

As a symbol of courage, generosity and beauty, Nausicaä has inspired many painters and sculptors throughout the ages, and it is after her that the largest aquarium in Europe has been named.

Today's aquarium with the same name (slightly adapted to Nausicaá) consists of several dozen aquariums and terrariums, with a total of 17 million liters of seawater and around 58 thousand marine animals from all around the world, enabling a breathtaking discovery of marine wildlife. Winding corridors lead visitors into an alien and uncanny world that keeps fascinating with its beauty and diversity. In one tank, delicately shimmering jellyfish float by, while in the next, swarms of sardines dart past. A few meters further, sharks glide gracefully through the water, barely moving their tail, while in an enclosure close by, penguins waddle along.

The most impressive part of the visit, however, is the largest aquarium of Nausicaá, a tank with 10 million liters of water where a complete ecosystem was built, modeled after the island of Malpelo in the Pacific Ocean. Here, hammerhead sharks, tropical fish, and reef fish swim by, and make the visitor feel part of the underwater world. But one sea creature, in particular, stands out with its impressive shape and size: the manta ray. With a wingspan of up to nine meters, these huge animals appear to be flying through the water. They owe their name to their characteristic big fins, which flap like wings. The name manta comes from Spanish and means "blanket."

But not only their appearance makes manta rays spectacular animals. They can leap an incredible two meters out of the water and spin before falling back into the water. Furthermore, manta rays have the largest brain to body size of all fish and a highly developed sensory system. An example of manta rays' cognitive function is their ability to recognize themselves in a mirror. These intelligent beings know how to collaborate and have complex social behavior. When feeding, for example, mantas "stack" on top of each other. The stack leader will eat, then another manta ray will lead, so that each one gets a turn. Additionally, when mantas find nutrient-rich areas, several mantas follow one another in a circle. By doing this, they create a spiral that traps the food allowing them efficient eating. Apart from their impressive intelligence, manta rays, which can live up to 50 years, are very hygienic. They wait up to an hour at certain reef locations to get cleaned by smaller fish.

The mantas' bodies are adapted to serve as a disguise. They are counter-shaded, dark on top, and lighter underneath. If viewed from a predator below, the white belly will camouflage them with light from the sun. On their "heads", mantas have cephalic fins that unroll when feeding and that look like small horns, giving the manta its nickname: the devil fish. Despite their nickname, mantas are gentle giants and do not represent a threat to humans. Manta rays have a "tooth band," made up of thousands of little teeth, which might seem threatening, but they do not use their teeth to hunt. To eat, they filter plankton, small fish, krill, crustaceans, and other food particles out of the water, using rows of tiny plates in their gills. When they are ready to eat, they unroll the fins by their mouth to help funnel the food into their mouth. They swim with their mouth open and chest cavity extended to allow water and food to flow in. The food gets filtered out of the water by the manta ray's gills allowing him to digest it.

This behavior caught our attention. How can the manta swim with its mouth open for minutes at a time, filtering food out of the water, without its gills getting clogged? This remarkable ability is due to the so-called ricochet effect, which we turned our attention to during our project. We dived deep into the ricochet effect to understand its mechanism and to try to use it as an inspiration to make a non-clogging water filter. Water filters are used in countless applications. They are necessary to preserve water quality and protect rivers and oceans from textile and plastic waste. For the last decades, a dramatic increase of microplastic in the environment has taken place. This microplastic affects humans as well as wildlife and it is of the utmost importance to address this issue. Most



filters used nowadays are filters that clog and need to be manually cleaned or replaced. A non-clogging filter inspired by the manta ray would be a great help to fight plastic and microplastic in our environment.

The manta ray also has special significance at the Nausicaá Aquarium, as the building is shaped like the sea colossus. In the oceans, finding a manta ray is a rare event, even for experienced divers. It therefore feels like an honor to watch this gentle giant from such close distance at the Nausicaá Aquarium. It is even more humbling, as the manta ray is listed as a threatened and vulnerable animal in the IUCN Red List. The threat to the existence of these animals is the rising demand in international trade, fishing, and bycatch. The trade for their gill plates is worth approximately \$30 million. Furthermore, branches of Chinese medicine have been increasing the demand for manta rays. The harvest rate is exceeding their reproduction rate, which is a slow process as the gestation period is 13 months and only 1 or 2 pups are born every 2 to 4 years. To address this problem, legislation has been created to protect manta rays. For instance, in Hawaii, criminal penalties and fines have been established for killing and capturing these animals in state waters. Peru has also passed legislation that bans manta fishing and forces fishermen to release any mantas caught as by-catch back into the ocean. While these laws help, manta rays as well as many other marine animals are still threatened by mankind. Walking through Nausicaás' big halls reminds us how small we are, what beauty can be found in the oceans and how crucial it is to preserve the treasures of the sea.

In our project, we tried to learn from the manta ray, hoping it will provide us with new solutions to filter microplastic out of the water. We hope to inspire others to learn from nature as well, in order to build a more sustainable future together.

# Assessing the Ricochet Effect as a Non-Clogging Method for Microplastic Filtration

## Abstract

This project investigated the suitability of a Manta Ray-inspired, non-clogging water filter to combat the worsening issue of microplastic water pollution. The Manta Ray is a source of inspiration as it can efficiently filter plankton from seawater to feed itself without its gills clogging. We examined the ability of the gills to create the so-called ricochet effect. This effect is created by the anatomy of the gills, which creates turbulent water swirls that make particles bounce off the gills while water can pass in between. In a first attempt to create a filter mimicking the manta ray, we tried to achieve the ricochet effect with a 3D-printed prototype. We were not able to recreate the ricochet effect with this method and, therefore, resolved to use simulations before testing our prototype in real life. The simulations showed that the ricochet effect can indeed be achieved in our prototype and that its effectiveness varies with different flow velocities and shape parameters of the filter. The next step in our project is to print the simulation-tested prototype and validate its effectiveness in real life.

### Background

The rising problem of microplastic contamination and pollution has been observed for several years. Already in the 1960s and 1980s, pieces of plastic were being found in the stomachs of several animals (Connors & Smith, 1982; Kenyon & Kridler, 1969).

Today, microplastic contamination and exposure to humans have become an inevitable problem. As reviewed by Marczynski and Lieleg (2021) and Prata et al. (2020), microplastic particles can come into contact with humans through their contamination of water and even air. As described in these reviews, microplastic can be detected in tap water, the air we breathe and products for daily use, such as shower gels, bottled beverages and honey. Another source of microplastic exposure is eatable fish. Considering the fact that up to 102 000 plastic particles per m3 were found in seawater close to a Swedish harbor (Norén, 2007), the contamination of fish is clearly a very urgent theme which needs more attention. Microplastic particles in general are considered particles smaller than 5mm (Moore, 2008). For ethical reasons, experiments on microplastic effects on human health are problematic. leading to the limitation that evidence for microplastic effects is mainly based on observational studies. Even though also strictly regulated, animal experiments can provide more detailed information about the main mechanisms of these particles. Despite these limitations, several studies show a convincing connection between microplastic particle exposure and pathological conditions (for more details and summary tables see Marczynski and Lieleg (2021)). These pathologies include respiratory, gastrointestinal and neurological diseases, such as COPD, Morbus Crohn, and Alzheimer's. Summarized as inflammatory diseases, this connection to microplastic is consistent with the reported potential reaction of the human body after being exposed to microplastic. As reviewed by Prata et al. (2020), contact with microplastic may lead to chronic inflammation and increased oxidative stress. Given that chronic inflammation diseases reduce healthy life expectancy (Kotas & Medzhitov, 2015; Radak



Figure 1: Ricochet effect visualization from (Divi et al., 2018). The blue and red lines show pathlines of water and particles contained in the flow. The grey geometry shows the filter elements.

et al., 2019), we need more focus and research on the effects of microplastic on the human body and how to avoid and reduce microplastic contamination in our products and environment.

This project aims to design a non-clogging microplastic particle filter that can help combat the highlighted issues. Inspired by the manta ray, the underlying mechanism that is used as the basis for this filter is the "Ricochet Effect." It uses the inertial mass of the particles in the fluid to leverage ricochet motion. Figure 1 shows the ricochet effect in motion.

As the particle size is orders of magnitude bigger than the dimensions of water, the system can be viewed as a colloidal suspension, in which the particle is being dragged by the water flow but reacts slowly to changes. When a particle hits one fin, it "bounces" back and due to its inertia doesn't follow the water around the obstacle.

If the distance to the next fin is just right, the same "Ricochet Effect" happens at the next fin resulting in a pile-up of particles above the fins.

If the distance between the fins is too large, the particle would just follow the water. On the other hand, if the distance is too small, the particle could in the best case "bounce" on the second or third next fin or in the worst-case scenario move down the next fin. When building a ricochet effect filter, one's calibration of fin size, the distance between fins, the contact angle, as well as the form of the fin, depends on the nature of the filtered particle, especially on its mass, average velocity suspended in the water, size and mass density.

When looking at the potential efficiency of such a filter, the amount of water that passes through the fins grows linearly with the number of fins; however, the loss of particles to the cleaned flow also grows exponentially. If you then want to reach the desired density of particles in the uncleaned flow, there should exist an optimal filter using the ricochet effect.

### **Goals and Methods**

This project takes off where previous related works on the ricochet effect stopped. In order to develop and commercialize ricochet effect solid-fluid filters, a design needs to be optimized and the effectiveness, when compared to established filters, has to be proven. Furthermore, use cases for the implementation of the filter have to be identified and proven. Therefore, the goal of the project was to develop and optimize a filter design using simulations and tests with 3d-printed prototypes to determine the filter efficiency and other flow properties of different designs and boundary conditions.

The design features to be optimized are the shape of the shell of the filter, the shape of the fins, the angle of the fins with respect to the water flow and the distance between the fins. The flow properties to be optimized are the flow speed and particle size.

The first proposed method was to 3d-print a modular prototype inspired by "Team Bats" in the Bionik Seminar at TUM and to optimize the fin design by replacing the fins and testing each design in a hardware test with a water pump. This first prototype is shown in Figure 2. After the first trial, we realized that hardware tests were extremely time intensive and that the water retention of the modular filter worsened after each reassembly. Therefore we decided to transition completely to fluid simulations instead. Here changing the filter design should be less time intensive and the water-tightness of the filter would no longer be an issue.



Figure 2: First 3D-printed prototype.

Ansys Fluent was used as the simulation software. For more time-intensive simulations, we gained access to the Leibniz Rechenzentrum's Linux Cluster. Simulations were carried out in the following sequence of steps. First, the 2D filter cross-section was modelled in SpaceClaim. Then a mesh of the flow area was generated. Next, the boundary conditions of the water flow were set and the particle injections were defined. At this point, the flow properties to be calculated were selected and then the simulation was carried out. Finally, the flow properties were read off and saved.

The setup is visualized in Figure 2. Here green represents the mesh, the blue arrows represent water flowing into the inlet and the red arrows represent water flowing out of the outlet. The top length is 15 mm, the bottom length is 10.4 mm, the height is 7 mm, the inlet size is 3 mm, the outlet sizes are 2.75 mm and the fins are 2.5 mm long and angled at 45 degrees.



Figure 3: Visualization of the filter setup. The blue arrows indicate water flowing into the filter inlet. The red arrows indicate water flowing out of the two outlets. The top and bottom outlets are the dirty and clean outlets respectively. The green lines represent the discrete 2-dimensional mesh generated for simulations.

### **Outcome and Discussion**

The simulations' results are summarized in Table 1 and the simulation parameters are listed in Table 2.

It can clearly be seen from the results that the percentage of particles filtered increases with the water flow velocity. Beyond an inlet flow velocity of 2 m/s, no particles were recorded exiting through the clean water outlet. A possible explanation would be that at larger flow velocities, the momentum of the water and the contained particles is too great to change direction and pass through the clean outlet. However, the percentage of water flowing through the clean outlet also increases with larger flow velocities, thereby proving that this is not the case. Instead, the ricochet effect seems to be effectively filtering out particles while letting water pass.

Inlet Flow Velocity (m/s)	Particle Mas Flow (kg/s)	% Water	% Particles
0.25	0.0025	18.4	9.44
0.5	0.005	18.5	2.70
1	0.01	22.0	0.0480
2	0.02	27.3	0.00
4	0.04	67.0	0.00
6	0.06	68.5	0.00

Table 1: Percentage of the inflowing water and particles that exit through the clean outlet for the different inlet flow velocities and particle mass flows tried in the simulations.

To validate the effectiveness of the ricochet effect we also analyzed the water velocity contours and visualized the movement of the particles. Figures 4 and 5 show the flow velocity profiles for an inlet flow velocity of 1 and 4 m/s. A strong difference in the two contours can clearly be seen. For the 1 m/s inlet velocity, the velocity profile of the dirty water remains almost unchanged whereas the clean water flow velocity is very close to zero. For the inlet velocity of 4 m/s, the velocity profiles in both the clean and dirty water flow change significantly from inlet to outlet. In the dirty water flow the flow velocity decreases, while it increases for the clean water flow. This reinforces the takeaway that the filter works best for larger flow velocities since a large proportion of clean filtered water is desired.

Figures 6 and 7 show the visualizations of the particle locations for an inlet velocity of 0.25 and 2 m/s. Similarly, to the previous two figures, the difference is very clear. For the lower inlet velocity of 0.25 m/s, the ricochet effect works poorly leading to particles being seemingly randomly dispersed throughout both the clean and dirty water flow. For the flow velocity of 2 m/s, the flow of the particles is very orderly and no particles can be seen in the clean water flow.

The weak effectiveness of the ricochet effect for lower flow velocities can be explained by the fact that it relies on turbulence.

Particle Diameter	Particle Density	Mesh Size	Wall Condition	Reynoldsnumber	Waterviscosity
0.45-0.5 mm	1.3 g/cm <sup>3</sup>	0.02-0.2 mm	Noslip	1660-19900	0.001003 kg/ms

Table 2: Simulation parameters



Figure 4: Flow velocity profile for an inlet flow velocity of 1 m/s.



Figure 6: Particle location visualization for an inlet flow velocity of 0.25 m/s

At low flow velocities, there is not enough energy in the flow for the necessary turbulences to form. On top of that, gravity exerts a downward force on the plastic particles forcing them downwards. Without the ricochet effect, nothing is stopping them from entering the clean water flow so it becomes contaminated.

Because the manta ray swims at a velocity of about 4 m/s we hypothesized that the effectiveness of the ricochet effect would peak at this velocity. The simulations showed that this hypothesis was false and that instead, the effectiveness continues to increase beyond this velocity. At 6 m/s there are still no particles in the clean water flow but the percentage of the water flowing through the clean outlet is slightly improved from 67 to 68.5 %.

## **Summary and Future Goals**

Our simulations showed that the ricochet effect is indeed a promising approach to building efficient, non-clogging filters. Furthermore, suitable flow velocities for the ricochet effect were identified. The unexpected complexity and time intensity of the simulations



Figure 5: Flow velocity profile for an inlet flow velocity of 4 m/s.



Figure 7: Particle location visualization for an inlet flow velocity of 2 m/s.

in Ansys Fluent prevented the investigation of other parameters within the scope of this project. Further simulations and prototyping would be necessary to confirm the results and to optimize the filter's geometry. Specifically, the project could be continued by:

- performing simulations with different filter designs
- building a prototype and testing the simulation results with a physical model
- identifying and testing suitable real-world applications (e.g. downstream of washing machines)

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## Self-reflection

One year and a half seemed like a long time when we started our TUMJA project, but our time at TUMJA is now almost over and we look back at this time, reflecting on our journey and all we have learned.

Our journey started in November 2021 during the first TUMJA weekend, when our interdisciplinary team of 7 was formed, bringing together the fields of study of mechanical engineering, medicine, physics, and business administration. Our original idea was to find inspiration in living membranes to create an efficient filter system. However, we soon decided to take our inspiration from marine wildlife instead and to mimic the gills of the Manta Ray. As we were attached to our team name Membrains, we decided to keep this name nevertheless.

As a team and as individuals, we learned a lot from our project. We learned how to cooperate and work as an interdisciplinary team, manage time and resources, and organize ourselves to maximize the work output. Our supervisors and tutors were of great help, entrusting us with the knowledge, experience, and contacts we lacked.

As time went by, we had to face many challenges of an organizational or technical nature. We all had many projects and obligations in parallel to TUMJA and working on our TUMJA project while also working on Bachelor's theses, Master theses, laboratory work, or being abroad, turned out to be our greatest challenge. Optimized work distribution and regular feedback helped us to overcome these challenges.

TUMJA also proved to be a great opportunity to meet many interesting and diverse people from all sorts of backgrounds and fields of study with many events promoting the exchange between the scholarship holders. We valued these events very much since they had not been able to take place for many months because of the Corona Pandemic and our predecessors had very few opportunities to meet in person. As a team, we got along incredibly well and enjoyed many shared team-building moments, which will remain valuable memories.

### **Acknowledgments**

Foremost, we wish to express our gratitude to our supervisors Prof. Dr Olivier Lieleg and Gwillem Mosedale for their support of our project and the knowledge and insights they shared with us, as well as for regularly challenging us, which helped us improve our project drastically. Their guidance was of great value to us.

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Thank you to Bernardo Miller Naranjo for helping us overcome the software difficulties we faced when running simulations.

We also wish to thank Thomas Fromm for his advice and training for writing the journalistic part of our research report.

Thank you to Misty Paig-Tran for advising us about her research on the Manta Ray's gills and the ricochet effect.

Last but not least, we would like to thank the TUMJA team and Peter Finger for the organization of all the TUMJA events, for his trust in our project, and for supporting all our ideas. Thank you for providing the tools to finish our project and for teaching us valuable skills for our future careers.

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## ТЛП

## Membrains

## A guest to an efficient, non clogging microplastic filter

**PROJECT STRUCTURE PLAN:** 

type in schools

I

We have split our team in three groups, which focus on unique challenges of our project. The first team tackles creating a working demonstration prototype. The second team will research the effect of microplastics on the human body and the third team will focus on spreading awareness about microplastics and maybe even presenting our project/proto-tione in scheole.

Membrains

#### PROBLEM:

For the last decades a dramatic increase of microplastic in the environment has taken place. Microplastic harms the fauna, the flora and human health. Studies have shown that humans consume a credit card worth of microplastics weekly.

#### SOLUTION:

To find a solution we have turned to filter feeders in marine wildlife. Two animals particularly caught our attention: Manta Rays and Salps. Manta Ray can filter seawater without gotting their gills clogged. This is possible due to the gills whose anatomy creates a water swirt which makes particles bounce off. Salps on the other hand, can litter particles smaller than the other hand. the pores in their filters.

Our main goal is to develop a real, working prototype. Our prototype should be able to make particles ricochet off itself and change the size of its pores. Furthermore, we want it to be able to filter microplastic ranging from 5 mm to 100 microns and to be compatible with pipes.



Our secondary goal will be to research the effects of micro-plastics on the human body and their abundance in food and the water supply. Our third goal will be to share the knowledge in schools.



### POSTER 1:

During the first months of our time at TUMJA, we took part in workshops that aimed at helping us define our project. We had decided to focus on the topic of "filters" but still had to narrow this subject down. Our first idea was to take inspiration from membranes to improve facemasks. However, we soon realized that the order of magnitude we would have to look at would be in the nanometer range. We decided that this range was too small for us to work on for the TUMJA project. Therefore, we shifted our attention to marine wildlife and in particular the Manta Rays and Salps. They seemed like a great opportunity to improve water filters. The first poster shows that we focused on defining our subject and covering the basics with a first explanation of the problem faced and the solutions we thought of. We split our team into subteams (Prototype, Human Health, and Contacts) and defined our goal. Furthermore, a first schedule was set for all the subtasks. 

## ЛШ

## Membrains

## A quest to an efficient, non clogging microplastic filter

For the last decades a dramatic increase of microplastic in the environment has taken place. To find a solution we are taking inspiration from **Manta Rays**. Due to their gills' anatomy, manta rays can filter seawater without getting their gills clogged.

#### **RESEARCH QUESTIONS:**

To what extent can micro plastic be filtered out of water more efficiently by a manta ray inspired filter as compared to other filters on the market?

Down to which size of particles can our 3D printed prototype filter via the ricochet effect?

#### WHAT HAS HAPPENED SO FAR?

Early in our research, we designed and 3D printed a first prototype. While testing we identified several flaws and decided to use fluid dynamics simulations to optimize the efficiency of our filter.

Obtaining simulation results proved to be challenging due to the cost of the licenses as well as the realization of the simulations. However, the first simulations already offered valuable insight, and made us rethink our design.

#### **METHODOLOGY:**

To test our hypothesis, and optimize our prototype, we will perform a parameter study through experiments and simu-lations while varying the following key parameters of our filter:

- >> angle between gills >> orientation in relation to the water flow >> spacing between gills

- >> spacing overveelinging
  >> size of gills
  >> number of gills
  >> shape (straight, bent or pointed)

Furthermore, we will determine the efficiency of the filter by introducing microplastic into the water upstream of the filter and measuring the amount that manages to pass through.

filtered amount initial amount

### POSTER 2:

During the following months, we continued working on our project. With the help of many constructive comments and workshops, we realized our goal was still too broad and would likely be hard for us to achieve. Once again, we narrowed down our goal, removing the Salps and the educational course from our focus. Furthermore, during a workshop weekend focused on project management, best practices, and core problem definition, we defined our research question. We also worked on the methodology, as can be seen on the poster. We explored several prototype designs and printed one. We changed the division of the team with the dissolution of the Human Health team and the creation of the team Simulations.









FIRST SIMULATIONS RESULTS



Laura Gentner, Tobias Loferer, Emilia Litzka, Lenz Pracher, Benjamin Villard Constantin von Witzleben, Julius Johannes Wenzler MEMBERS TUTORS Martin Zimgibl, Dina Aladawy SUPERVISORS Prof. Dr. Oliver Lieleg, Gwillem Mosedale HELPERS Bernardo Miller Naranjo, Hristiyan Vasilev

inspired by

## ТШП

POSTER 3:

## Membrains membrains A quest to an efficient, non clogging microplastic filter

#### WHAT IS OUR RESEARCH ALL ABOUT?

What is observed to the second second



#### 2. To what extent can particles be filtered by our filter design?



WHAT HAS HAPPENED SO FAR?

PROCESS AND MILESTONES Early in our research, we designed and 30 printed a first prototype. While testing we identified several flaves and decided to use fluid dynamics simulations to optimize the efficiency of our filter. After chang-ing our approach we had to tackle the issue of computing ressources, cost of the licenses as well as the realization of the resolutions, cost of the licenses as well as the realization of the simulations. However, as the first simulations already offered valuable insight and made us rethink our design, we tried to get access to the LRZ Cloud for efficient simulations. We are currently in the process of making the best use of the newly gained possibilities and achieving the optimum problem solution by varying the parameters of design, gill spacing and anote. and angle

MOST IMPORTANT RESULTS As described above, our first prototype had several flaws, which included the problem of the quality of 3D printers. As a consequence, we shifted our main work towards simulations. After intensive research, we decided to use the Ansys software for our project, because this software is very efficient and easy to handle. By the help of a Ph.D. Student, we achieved to create the first successful

NEXT STEPS As In our further timeline, we plan to finalize our simulations. Overall we have to run 27 simulations, since we want to test three different conditions for each of our three parameters. In order to do so, we have to set up a meeting with experts, who will help us to clarify the final settings for this task. Additionally we have get familiar with the LR2 cloud interface, because our simulations will be run there. Further-more we will also start to write our research report. Once the simulations are finished, our goal is to evaluate the data and to build a promising protetype.



After printing our first prototype, we tried to test the ricochet effect using a water pump and our 3D-printed prototype. However, testing turned out to be more challenging than expected, as our prototype was severely leaking and water motion was complicated to see with bare eyes.

We realized that simulations offer a more efficient way to test the parameters and, from that point, we decided to focus on these instead. Once our simulations gave us the optimal parameters for our filter, we planned on printing it once more. We furthermore improved our research questions and created a Logo, representing a Manta Ray, which can be seen at the top of the poster.

## ЛШ

POSTER 4:

## The last poster shows the final result of the project. Through simulations, we were able to produce a proof of concept for the ricochet effect and show connections between the few defining parameters of the system. We will now print our optimized prototype and test it in real life, using plastic particles. In terms of the three objectives from the first poster, we focused on the main one: to build a water filter inspired by the Manta Ray. We have seen a shift in objectives throughout our project and the timeline was adjusted several times over the course of the project.

## Membrains CHENDRATHS

A quest to an efficient, non clogging microplastic filter

#### INTRODUCTION

For the last decades, a dramatic increase of microplastic in the environment has taken place. To find a solution we investigated the suitability of a Manta Ray-inspired, non-clogging water filter to combat the worsening issue of microplastic water pollution. The Manta Ray is a source of inspiration as it can efficiently filter plankton from seawater to feed itself without its gills clogging. We examined the ability of the gills to create the so-called incohet effect. This effect is created by the anatomy of the gills, which creates turbulent water swirts that make particles bounce of the gills while water can pass in between.

#### **RESULTS OF OUR RESEARCH**

Our simulations showed that the ricochet effect is indeed a promising approach to building efficient, non-clogging filters. Suitable flow velocities for the ricochet effect were identified.

#### FIGURE 1:

Visualization of the lifter setue. The blue arrows indicate water flowing into the filter infet. The red arrows indicate water flowing out of the two outlets. The top and bettern outlets are the dirty and class notice reagestively. The green lines represent the discrete?-dimensional mesh generated for simulations.



FIGURE 2: Fiew velocity profile for an inlet flow velocity of 4 m/s



Particle Disenses | Particle Density | Mesh Size | Wall C

Print the optimized Filter and test it in real life.

NEXT STEP

The simulations' results are summarized in Table 1 and the simulation parameters are listed in Table 2.

Intel Flow Webcity (mit) Particle Mass Flow Jupit) 5 Weber

FIGURE 3: CAD model of the new filter

MEMBERS Laura Cantone, Emilia Litzka, Tobias Lofene, Lanz Pracher, Benjamin Villard Constantin voc Witzbehou, Jalus Johannes Wenzler TUTORS Dina Aladawy, Martin Zimgibi SUPERVISORS Prof. Dr. Oliver Lieleg, Gwillem Mosedale HELPERS Bernardo Miler Naraje, Instityan Vasilev MAY 2023

## inspired by



## Project Report SustainAct

Environmental concern and awareness of proper waste treatment is generally attributed to the academic environment. In our project SustainAct, we tried to find out whether TUM can actually be attributed a pioneering role in waste separation. To this end, we conducted an online survey among TUM students, staff and alumni to ascertain the current status of waste separation and to investigate potential for improvement. The results show that there is a strong awareness for waste separation, but that the possibilities for correct separation on site are not always given, which indicates potential for optimization. Recommendations for promising measures are given, emphasizing the importance of a TUM-wide approach.

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Team	Aastha Chandiwala Moritz Ptacek Corinna Winkler
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## Preface by the Tutors Veronika A. Bauer and Rodrigo de Rojas



Waste is one of the most crucial problems of our generation. For years, the amount of waste being produced has been steadily increasing. Waste gets thrown away thoughtlessly, pollutes landscapes, rivers, the sea. Even at the bottom of the Mariana Trench, the world's deepest oceanic trench, waste has been found. One important method in the fight against waste pollution is garbage separation. It not only supports waste avoidance but also enhances the retrieval of resources. Especially in times of increasing resource scarcity, recycling is key.

Waste separation is a crucial process that targets the efficient management of waste materials in any community. In Germany, waste separation is mandatory and has become part of the DNA of many of us. Waste separation has gained significant attention in various sectors, including educational institutions.

Personell within the university structure play a critical role in the successful implementation of waste separation, including the waste management team, the cleaners and sanitation workers, and the faculty and students.

Many TUM students and employees have integrated waste separation into their daily university life even though the amount of waste that is correctly separated at TUM still admits of improvement. This issue has also been recognized by team SustainAct. In collaboration with the Green Office Weihenstephan, the team developed and conducted a survey, revealing many of the obstacles to successful waste separation whilst showing how waste management can be improved.

Despite an uneven start, the loss of many team members, and several setbacks, all three members of SustainAct committed to this important topic. With dedication, motivation, and curiosity, SustainAct asked about 170 members of TUM on how to improve waste management at TUM. The enthusiastic feedback is proof that SustainAct really hit a nerve. Now it is up to TUM to take advantage of this opportunity, build robust waste separation policies and guidelines and step up their waste management game.

## Excellence and Sustainability: Implementation Remains a Challenge

With its breathtaking views of the Alps and vast green spaces, the Weihenstephan campus occupies the Weihenstephaner Berg. This expansive campus rarely sees large crowds as students are dispersed among various buildings. It is a perfect setting for discussions on sustainability at the Technical University of Munich (TUM). The Freising campus, known as Weihenstephan, is often cited as a shining example. Here, approximately 5,000 students immerse themselves in "Life Sciences," fields closely intertwined with nature.

A revealing scene unfolds at lunchtime, as hunger lures students out of lecture halls, offices, and the library towards the cafeteria. Discarded gum wrappers, coffee cups, and scribbled papers accumulate. But where can environmentally conscious students and staff dispose of their waste without resorting to general waste bins? As early as 2001, TUM implemented a comprehensive waste management system in Freising, placing significant emphasis on waste separation. More than 40 "Müllinseln" (recycling islands) with dedicated bins for different types of waste were strategically positioned across the campus. The aim was to provide waste separation facilities in offices as well. However, a stroll around the campus reveals that waste separation is not always straightforward. While some buildings offer proper waste separation options, many others lack clearly labeled bins or only provide general waste bins.

To address this issue, TUMJA launched a project, "SustainAct," to assess the state of waste separation at various TUM locations. They conducted a quantitative survey among students and staff, which exposed weaknesses in the current waste management practices. Feedback from approximately 170 participants high-lighted concerns. Some students questioned the availability and labeling of waste bins, expressing frustration with the difficulty of identifying the appropriate bin. Meanwhile, employees voiced their exasperation with waste disposal companies, lamenting the futility of waste separation efforts when cleaning services simply mix everything back together. "We have been complaining about this for years, drawing attention to the issue, but nothing changes,"

one employee emphasized. Despite these challenges, some resourceful individuals devised their own waste separation systems, overcoming the lack of clarity. However, there remains uncertainty about whether the cleaning staff will adhere to these efforts, prompting suggestions to involve them in awareness campaigns.

Recognizing the issue, the TUM Green Office Weihenstephan has taken action. Committed students are working towards implementing TUM's sustainability strategy at the Weihenstephan campus. Collaborating closely with the Waste Management and Environment department of TUM Campus Management, they have developed a waste separation strategy for kitchens and common areas in departments, led by Prof. Sara Leonhardt and the Chair of Plant-Insect Interactions. This strategy is set to be implemented soon. Furthermore, plans are underway to launch an awareness campaign featuring posters promoting proper waste separation. The survey also revealed ideas for measures that could facilitate waste separation in daily life. Participants expressed a desire for more information on the fate of the waste they separate, suggesting that showcasing the recycling processes in the Munich area and Straubing could enhance motivation for proper waste disposal. An information campaign holds promise. Additionally, given the inconsistent availability of suitable waste bins, it is crucial to integrate sustainability criteria into waste management practices and ensure compliance from third-party cleaning companies.

The Weihenstephan campus stands as a symbol of excellence and sustainability, yet challenges in implementing effective waste separation persist. However, concerted efforts and initiatives are underway to address these issues and foster a greener future for the university community.

## SustainAct – Waste Separation at TUM

### Abstract

Our modern society is characterized by consumerism, often referred to as a leading cause of environmental pollution, which continues to stress ecosystems all around the world. Consequently, the importance of Mother Nature and the pressing need to preserve it for future generations is increasingly becoming the focus of today's society. Waste separation is hereby seen as one of the basic concepts to reduce disposal of waste into ecosystems.

Environmental concerns and awareness of the need for proper waste treatment are generally seen as notable attributes of academic environments. Universities all around the globe are depicted as showpieces for waste separation, as they are seen as entities already having implemented comprehensive environmental policies. In our project SustainAct, we tried to find out if a position on the frontier of waste separation is actually to be attributed to TUM. Thus, we surveyed the current status of waste separation and investigated potential areas for improvement.

For this purpose, we conducted an online survey among students, employees and alumni of TUM. We generated preference weights for different measures to improve waste separation, following the analytical hierarchy process (AHP) methodology. The analysis of relational data required compositional data analysis (CDA). The results show that there is strong principled commitment to waste separation among TUM employees and students, but possibilities to perform separation correctly on site are not always available, pointing to potential points of optimization. Advice on promising measures is given, stressing the importance of a TUM-wide approach.

## 1. Background

Germany was for a long time considered a perfect example of a "throwaway society," as were other leading industrial nations. Products were disposed of en masse after a single use, broken items were replaced with new ones instead of being repaired and reused. As a result, this led to enormous amounts of environmentally harmful packaging waste. In recent years, for example, up to 13.1 million tons of residual waste have been generated each year, which is equivalent to the weight of 1,300 Eiffel Towers and around 5 million tons of CO2eq. To absorb this amount of CO2, a forest area of 500,000 ha would be required, which is 2.5 times the area of Monaco (Umweltlifeguide-Nachhaltig Wohnen und Leben in München, 2023). Converted to individuals, private households recorded an average of 78 kilograms of packaging waste per capita in 2020 (Die Bundesregierung, 2023). However, this is not a problem limited to Germany, but a global challenge that needs to be addressed.

One possible approach to solving this problem is to move away from a "throwaway society" and toward a circular economy. The aim is to close material cycles by reusing all waste as raw materials and thus conserving natural resources. Hence, a circular economy represents effective climate and resource protection and, at the same time, offers an opportunity for sustainable economic development and new employment (Die Bundesregierung, 2023).

Germany has therefore embarked on such a path with developments towards a more sustainable use of natural resources. Thus, since June 1, 2012, the Closed Substance Cycle Waste Management Act (Kreislaufwirtschaftsgesetz) has provided the legal framework for waste management in Germany. The law's purpose is to promote a circular economy in order to conserve natural resources and to reduce environmental pollution (Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz, 2023). In this context, Germany applies the so-called principle of waste hierarchy from waste avoidance to reuse, recycling and other recovery, with disposal as ultima ratio (Die Bundesregierung, 2023).

Recycling in particular is an important element of a circular economy. It involves recovering raw materials from waste, keeping used materials in a continuous life cycle by processing them into new products, ultimately reducing the amount of waste. Almost all waste is suitable for recycling, especially glass, paper and cardboard, plastics, but also iron and metals. Used glass can be remelted and reprocessed as often as desired. Moreover, the use of recycled paper conserves forests and contributes to climate protection. It also performs significantly better in terms of wastewater pollution, and of water and energy consumption, than paper products made from the primary fibers of pulp and groundwood. Proper separation of waste is essential for recycling, especially when it comes to plastics and packaging waste. In addition, valuable raw materials such as aluminum, iron, nickel and lead can be recovered, e.g. from spent batteries in special processes (Die Bundesregierung, 2023).

However, despite a recycling rate of 79% (Die Bundesregierung, 2023), achieved even though 40% of compostable organic waste is disposed of in residual waste (Umweltlifeguide-Nachhaltig Wohnen und Leben in München, 2023), too much packaging waste is still produced in Germany. Legal requirements have been introduced to avoid single-use plastic and to strengthen reusable offerings. For example, numerous single-use plastic products have been banned throughout the EU since July 2021, and lightweight plastic bags since January 2022. The majority of plastic beverage bottles are now recyclable. In order to recover more recyclable materials, higher recycling rates were introduced for all types of packaging in January 2022. For this reason, at least 90% of packaging made of ferrous metals, aluminum, glass, paper, cardboard and cartons must be recycled, while the minimum rate for beverage cartons is 80% and for plastics 63%. In addition, the proportion of plastics in bio-waste that is composted, fermented or mixed with other materials must be reduced to a maximum of 0.5% (Die Bundesregierung, 2023).

In order to improve waste recycling, the waste separation requirement is to be strengthened in the future. Accordingly, public waste management authorities are obliged to collect biowaste from private households separately in order to subject it to a high level of material recycling such as composting (§ 20 Absatz 2 Satz 1 Nummer 1 KrWG). This serves to improve regular waste recovery in the sense of the waste hierarchy mentioned above (§ 9 Absatz 1 i. V. m. § 7 Absatz 2 bis 4 und § 8 Absatz 1 KrWG) (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit, 2021).

Correct waste separation is therefore an essential prerequisite for proper recycling and thus the foundation of sustainable waste management. Packaging must be sorted correctly according to material type so it can subsequently be processed in an environmentally friendly manner. Residual waste is incinerated unsorted, while bio-waste is used to generate energy such as electricity and heat (Umweltlifeguide-Nachhaltig Wohnen und Leben in München, 2023). As already mentioned, waste separation is legally prescribed in the Closed Substance Cycle Waste Management Act §14 (1) and, as a global challenge, concerns every individual in our society. Its non-observance is associated with the loss of valuable resources, dramatic environmental consequences and enormous economic costs (Mülltrennung-wirkt, 2023).

As a university institution with wide-reaching influence, TUM has an obligation to take up and advance solutions to social problems like waste separation. It is striking that TUM has not yet implemented a uniform strategy on waste management. The availability of trash bins that allow for waste separation seems to vary widely across campuses. While some offices are equipped with trash bins for paper and mixed trash, there are several offices with only mixed ones. Similar observations can be made in public spaces. Buildings on campus are mostly equipped with trash bins for mixed waste, while multi-purpose trash bins are rare. A lack of reusable bins can also be observed at the WZW campus in Freising. In 2019, a new waste management strategy was implemented at WZW. New trash bins are to enable waste separation. For this purpose, so-called "trash islands," i.e. places for central trash collection, were set up throughout the campus. However, there do not yet seem to be any facilities for waste separation in the public areas and offices. Thus, waste separation is mainly possible at the "waste islands."

The objective of this study is to investigate the current status quo of waste separation at TUM and to offer some suggestions for improvement strategies and indicate their benefits.

### 2. Methodology

## 2.1. Analytic hierarchy process (AHP) and compositional data analysis (CDA)

With several campaigns planned to improve waste separation at TUM, the goal of this study was to capture the status quo of waste separation at TUM. A further target was the identification of promising measures which could help to improve waste separation. The results should help with the development of promising measures capable of enhancing waste separation, especially by uncovering the average importance of each measure, as well as the heterogeneity in preference.

The following five measures for improved waste separation were compared:

- 1. More multi-purpose bins (Bins)
- 2. More bins of the current type, meaning less time to the next bin (Time)
- 3. Content information on each bin, for example stickers listing items belonging in the respective bins (Information)
- 4. Campaign for higher awareness of the importance of waste separation (Awareness)
- 5. Improved waste treatment by disposal companies (Collection).

A comparison of different measures would facilitate a labeled discrete choice scenario. While the different measures could be described and compared based on attributes, there is no realistic scenario that incorporates a price attribute. This assumption is grounded on the idea that waste separation lies within the responsibility of TUM as an organization. Neither students nor employees would be willing to pay for measures on waste separation; neither would they be willing to accept compensation for sub-optimal separation possibilities. Proper disposal and treatment of waste should have been a long-established given. It is, as a result, not possible to construct a utility function, ruling our discrete choice analysis.

The analytic hierarchy process (AHP) invented by Saaty (1977, 1980) is a weighting method that can be applied in case a utility function cannot be formulated. The first step of AHP is problem formulation. Next, respondents prioritize alternatives based on individual comparisons, stating the importance of an attribute in relation to another attribute. A comparison of each pair of attributes leads, in the five-attribute case, to ten comparisons. Priorities are calculated once data is collected. It is possible to generate individual and aggregated priorities (Ishizaka, 2013).

A consistency check ensures that the transitivity and reciprocity rules are respected (Ishizaka, 2013). Saaty (1977) developed a consistency index, which is based on the eigenvalue

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

with  $\lambda_{max}$  as the maximum eigenvalue. A comparison of the consistency index with the average consistency ratio of 500 randomly generated matrices, leads to the consistency ratio of each matrix.

$$CR = \frac{CI}{RI}$$

The random index with five attributes and 1000 simulations was set to a value of 1.115356. Figure 1 shows the consistency ratio of individual matrices using linear scaling. The weighting matrices show high inconsistency, which would lead to inconsistent aggregated priorities. Harker's method can be applied to reduce the inconsistency in individual preference matrices (Saaty, 2003). The most inconsistent pairwise comparison of each matrix is replaced by a consistent weight based on the eigenvalue. This process can be repeated several times, with each iteration leading to a loss of information. The number of iterations should hence be kept as low as possible.

Transforming the preference statements from a linear to a logarithmic scale increases consistency (see Figures 1 and 2).

The first iteration leads to an increase in consistency, while further iterations only have marginal effects. The logarithmic transformation in combination with one iteration of Harker's method was applied to deduct priority weights.



Figure 1: Consistency of compositional data after one iteration following a linear weighting by Saaty (1977)



Figure 2 Consistency of compositional data after one iteration following a linear weighting by (Ishizaka et al., 2006)

The generated priority weights resemble compositional data. Handling compositional data requires special care. The Simpson's Paradox explains a prominent issue when it comes to aggregation of compositional data. In the following example, the share of male and female students arriving late to class is recorded in two classrooms (see Figure 3). The aggregated arithmetic means indicate that more men than women were on time if aggregated over both classrooms, even though the share of female students arriving on time is larger for both classrooms (Pawlowsky-Glahn, 2013). Geometric means are applied to avoid problems with arithmetic space.

277	Classro	om 1	Classro	om 2	Tot	al
	On time	Late	On time	Late	On time	Late
Men	53	9	12	6	65	15
	0.855	0.145	0.667	0.333	0.813	0.188
Women	20	2	50	18	70	20
	0.909	0.091	0.735	0.265	0.778	0.222

Figure 3: Example of Simpson's Paradox from Pawlowsky-Glahn et al. (2013)

### 2.2 Analysis of compositional data

Statistical analysis of compositional data does not follow classical statistical properties. Compositional data is part of the so called simplex, or compositional space. Compositionally equivalent results can be achieved with different levels of physical amounts, as represented by points P and P' in Figure 4. Point P could represent a fixed share of renewable energies in the national energy produc-

tion mix. Point P' is compositionally equivalent, which could be achieved by an increase in renewable energy production, just as with a reduction in non-renewable energy production.



Figure 4: Simplex imbedded in  $\mathbb{R}$  3 (a) and Ternaty Diagram from Palowski (2015)

Special care has hence to be taken if composition data is to be analyzed with conventional statistical techniques. All conventional calculation methods can be applied once the compositional data has been transformed using the Isometric Logratio Transformation (ILR). All common mathematical operations are viable once the data is transformed, but interpretation is not straightforward due to the factorial character of the transformed data (Palowski, 2015).

### 2.2. Aggregation of variables for analysis

Several control variables were aggregated for analysis. The campuses of Heilbronn, Ottobrunn and Singapore were aggregated to one campus due to a low number of observations. Participants were further grouped into three income groups, with 25 percent of respondents having a monthly income below  $1.000 \in$ , 50 percent of observations with a medium income between  $1000 \in$  to  $2.200 \in$  and 25 percent of respondents with a "high income" above the q75 value of  $2.200 \in$ . Two age groups consisting of individuals below and above the median age of 28 years are distinguished.

The attitude of participants towards nature is controlled by following the standardized approach "NR-6", which is a standardized approach in psychology to measure environmental relatedness. This approach is often followed as a control due to it's small item battery of six questions only (Nisbet, 2013).

## 3. Outcome and Discussion

### 3.1. Demographic Data

Our survey encompasses data from a total of 175 respondents. The responses of four participants had to be removed due to erroneous answers, resulting in a final sample size of 171 participants. Among these respondents, there were 79 students and 95 employees of TUM. Interestingly, 6 of the employees were also students at TUM. Additionally, 3 TUM alumni took part in the survey.

The participants represented various TUM campuses, including TUM city, Garching Forschungszentrum, Freising (WZW), Straubing, Heilbronn, Ottobrunn, and Singapore (Table 1). They also belonged to different Schools and Faculties within TUM (Table 2).

In terms of gender distribution, approximately 60% of the participants identified as female, while 40% identified as male (Table 3). Given the significant number of employee participants, the age range varied from 18 to 62 years, with a median age of 28 years.

Campus	Number of participants
Munich City	56
Garching Forschungszentrum	50
Freising (WZW)	31
Straubing	25
Heilbronn	2
Ottobrunn	1
Singapore	2

Table 1: Number of participants from each TUM campus

School or Faculty	Number of participants
TUM School of Computer, Information and Technology	25
TUM School of Engineering and Design	33
TUM School of Natural Sciences	32
TUM School of Life Sciences	31
TUM School of Management	19
TUM School of Social Sciences and Technology	8
Faculty of Medicine	6
Faculty of Sport and Health Sciences	3
None	14

Table 2: Number of participants from each TUM school or faculty

Gender	Number of participants
Male	64
Female	103
divers	0
NR	4

Table 3: Number of participants sorted by identified gender

Another demographic factor analyzed was the monthly income of the participants, who had an average income of  $2,150 \in$  and a median of  $1,700 \in$ . Respondents' nature relatedness, with a mean score of 3.8, above average, indicates slight selection bias towards high environmental awareness.

## 3.2. Status Quo of Waste Separation at TUM Campuses

The results show that the majority of participants (over 90%) consider the effect of waste separation on the environment to be beneficial (Figure 5). Furthermore, a high level of agreement with the principle of waste separation in general is found among the participants (Figure 6). The results further reveal that a majority of participants believe that individual waste separation is more efficient than waste separation at the trash yard (Figure 7).





Knowledge about a TUM-wide color scheme for waste bins is heterogeneous, indicating a lack of uniformity in participants' perceptions (Figure 8).

Appropriate use of waste bins depends on the type of trash. Paper is separated into a bin for paper waste, while glass is often thrown



Figure 6: Level of agreement with statement that waste should be separated rather than mixed in absolute numbers







Figure 8: Agreement of participants regarding uniformity of color scheme of trash bins at TUM in absolute numbers

into mixed-trash bins. Our results indicate that plastic-metal composites are not separated similarly, with only a small share of respondents indicating that plastic-metal bins (yellow bag) are used. More than 50% of the participants disagree that bio-waste bins are used correctly (see Figure 9).



Figure 9: Correct use of waste bins with respect to different waste categories from strongly disagree to strongly agree

About 60 percent of the respondents state that they are willing to invest extra time to use a multi-purpose instead of a mixed bin. While this is a promising result, questions on actual use of waste bins with respect to the time needed to find a bin indicate a gap between willingness to separate and actual waste separation practice (see Figure 10). It takes too long to find a waste bin for biological or plastic-metal composition material. Answers regarding pa-



Figure 10: Low availability of trash bins with respect to different trash categories from strongly disagree to strongly agree

per bins are more heterogeneous, indicating that even separation of paper is not always possible. Only mixed-trash bins are largely reached in time.

More than 80% of the participants agreed that more efforts could be made to reduce waste (Figure 11). This indicates that waste management is not sufficient.



Figure 11: Agreement of participants regarding necessity of more efforts on waste mitigation in absolute numbers

### 3.3. Descriptive Results of the Compositional Data

Potential measures to improve waste separation were weighted by each respondent. The geometric mean of the preferences shows that the installation of more multi-purpose bins and improved waste collection and management are the most preferred measures (see Figure 12). Awareness campaigns and information on trash bins are less favored. With less time to the next bin, the least favored, there is an indication that waste separation is not hampered by the quantity of available trash bins. The geometric means reveal a large heterogeneity across respondents. Improved waste collection and management shows the largest upwards directed standard deviation, further indicating that improved trust in the waste change after disposal by the individual could be a promising measure.

Targeted measures can only be applied if the large heterogeneity in the preference weights is dismantled. The data on geometric means by campus seem to add little explanation (Figure 13).

Respondents from the campuses Munich city and Straubing weigh more multi-purpose bins approximately 5 percent more important

Aggregated Preference Weigths Applying Logarithmic Scaling



Figure 12: Aggregated geometric mean of preference weights of different measures to improve waste separation





Figure 13: Compositional Data Analysis - Comparison of waste treatment measures across campuses of TUM

than at other campuses. An awareness campaign seems to be less promising in Straubing, while Straubing and Garching place the highest weight on improved garbage collection and management. The category of other campuses seems to diverge significantly, with an awareness campaign as the most promising measure.

Geometric means were also calculated for each school of faculty of TUM, again with evident differences in preference weights (Figure 14).

Students and employees from the faculties of Medicine and Sport and Health Sciences put great importance on provision of more



Figure 14: Compositional Data Analysis - Comparison of waste treatment measures across schools and faculties of TUM

bins (>30%) and are closely followed by the School of Management. There seems to be no difference in the preference for a measure introducing more bins. A comparably large share of participants from the Faculty of Sport and Health Sciences would like to have more waste separation information on the bins. An information campaign seems to be less promising at the School of Management and the Faculty of Sport and Health Medicine. There seem to be further differences of importance regarding improved waste collection, with members of the Faculty of Medicine and



## Importance of Waste Treatment Measures Across Affiliation

Figure 15: Compositional Data Analysis - Comparison of waste treatment measures across affiliation to TUM Sport and Health Sciences considering improvements in this direction less important.

Differences between employees and students are small, which seems logical considering that both groups should mostly use the same facilities.

Alumni of TUM diverge from active members, as they seem to put more weight on improvements on the waste chain after trash disposal and less weight on an increase in the number of trash bins, indicating that time constraints are less important for this group (Figure 15).

There is almost no difference in the importance of measures for improved waste separation across gender (Figure 16).



Importance of Waste Treatment Measures Across Gender

Figure 16: Compositional Data Analysis - Comparison of waste treatment measures across gender

Males seem to put slightly more weight on improvements of the quality of currently available bins. This is largely compensated by the measure of improved garbage collection after disposal, which females find to be more promising. The small group of non-binary participants prefers installation of more bins if compared to males and females, while this group seems more reluctant about an awareness campaign.

Differences between international and German students seem to be minor, with a small tendency that international students see more bins of the current type to be more important compared to Germans. International students do meanwhile put less weight on an information campaign (see Figure 17).



## Importance of Waste Treatment Measures German vs International Participants

Figure 17: Compositional Data Analysis - Comparison of waste treatment measures across country of origin

Differentiation by income reveals that members of TUM with a medium income seem to differ from the low and high income groups, which are very similar. Medium income members of TUM seem to put more weight on increased number of trash bins of the current type, and hence less time to the next bin, while an awareness cam-



Importance of Waste Treatment Across Income Levels

Figure 18: Compositional Data Analysis - Comparison of waste treatment measures across income levels

paign and information on the content of bins are less attractive for them (see Figure 18).

Comparing the importance of the mentioned measures between age groups, no individual tendencies could be identified (see Figure 19).



Importance of Waste Treatment Across Age Groups

Figure 19: Compositional Data Analysis - Comparison of waste treatment measures across age groups

### 3.4. Measures for better waste separation and causality

An ordinary OLS regression on the ILS transformed data hints at a few causal relationships. Results with a p-value below 10 percent are discussed here, arguing that the sample size of 154 observations is quite low, most likely causing the remaining uncertainty. The coefficients and their p-values are reported in table 4.

The first regression unravels and differences in preference for the two measures More Multi-Purpose Bins (A) and More Bins of the Current Type (B). There is a weak but marginally significant causality between the ratio and the variables age and income, indicating that both older and respondents of higher income favor more bins of the current type over more multi-purpose bins. This observation holds for international students and the campus of Garching, as well. There is also a difference between genders, with male respondents putting more weight on a measure that increases the number of multi-purpose bins, instead of just increasing the number of trash bins currently in place.
## SustainAct

Dependent Variable	A/B		AB/C		ABC	/D	ABCD/E		
	ß	p-value	ß	p-value	ß	p-value	ß	p-value	
Intercept	-0.24093	0.41	-0.27626	0.42	-0.48097	0.18	-0.45286	0.30	
Age	0.00836 .	0.10	-0.00291	0.62	0.00558	0.36	0.01238	0.10	
Income	0.00004.	0.05	0.00000	0.84	0.00001	0.69	0.00000	0.93	
Male	-0.17084 .	0.06	-0.14869	0.16	-0.10218	0.35	0.00080	1.00	
Time of Affiliation	-0.00333	0.67	0.00857	0.36	-0.00940	0.33	-0.00846	0.47	
NR-6 (Nature Relatedness)	-0.05878	0.35	0.16602 *	0.03	0.21029 **	0.01	0.03611	0.70	
Working Days	0.00769	0.80	0.02477	0.48	-0.04224	0.25	-0.01625	0.72	
Mitarbeiter	-0.12520	0.25	-0.06322	0.62	-0.09619	0.47	-0.03211	0.84	
Alumni	-0.27676	0.41	0.18924	0.48	-0.14688	0.72	0.74476	0.14	
International	0.29714 **	0.01	-0.16359	0.19	-0.27182*	0.04	0.10707	0.50	
Garching	0.22638 .	0.08	-0.19657	0.20	-0.05964	0.70	0.16590	0.39	
Freising	0.04724	0.81	-0.19132	0.41	-0.21034	0.38	-0.05072	0.86	
Straubing	0.04800	0.74	-0.21099	0.22	-0.35979 *	0.04	0.24568	0.25	
Other Campus	0.16653	0.55	-0.24595	0.45	0.40023	0.24	0.06689	0.87	
Engineering	-0.07638	0.56	-0.3305 *	0.03	-0.24020	0.14	0.08119	0.68	
Natural Sciences	-0.04815	0.73	-0.11350	0.49	-0.14363	0.40	0.09687	0.64	
Life Sciences	-0.17226	0.39	0.05092	0.83	0.17911	0.46	0.17340	0.56	
Management	-0.10361	0.51	-0.35219 .	0.06	-0.29578	0.12	-0.10684	0.65	
Social Sciences	0.23487	0.27	-0.32762	0.19	-0.16050	0.54	0.08361	0.79	
Medicine	-0.26613	0.26	-0.43604	0.12	-0.33556	0.25	-0.03671	0.92	
Sport	-0.40813	0.28	-0.50314	0.26	-0.75981	0.10	-0.70237	0.21	

Table 4: Regression on ILR transformed preference weights

Regression on Isomeric Log-Ratio transformed waste separation measures

A = More Multi-Purpose Bins, B=More Bins of current type, C=Content Info on Bins,

D=Awareness Campaign, E=Improved waste treatment after disposal n=154

The comparison of AB with C can be interpreted as the relative importance put on an improvement in the quality of the trash bins (more bins or better bins) compared to a measure where information is given on how to use existing bins. Members of the School of Engineering and Design and the TUM School of Management weight improved quality of trash bins as significantly more important than more information on the current bins than members of the TUM School of Computation, Information and Technology. The same trend holds for members of the TUM School of Medicine, although being marginally insignificant at the 10 percent confidence level. Another finding is that respondents with a high nature relatedness score favor information on bins over bin quality. This may indicate that people of high environmental awareness suffer lower disutility from searching for waste bins and are hence happier with the current availability and quality of trash bins, but are more concerned about correct waste separation. The third regression uncovers tendencies in a comparison of bin-related measures (A, B and C) and an awareness campaign. The higher the environmental awareness, the more weight is put on an information campaign as compared to bin-related measures. This, again, could hint at lower levels of concern about the current waste separation system among environmentally sensitive TUM members. Another explanation could be low trust of environmentally oriented members in the waste separation behavior of their peers. International students meanwhile attribute significantly lower importance to an awareness campaign as compared to German members. The campus of Straubing differs from other campuses. Bin-related measures are seen as significantly more important than an awareness campaign. Although marginally insignificant at the 10 percent level, there is a clear tendency that members of the School of Engineering and Design, TUM School of Management and faculty of Sport and Health Sciences put less weight on an information campaign. This finding is especially interesting for the Schools of Engineering and Management, as both weighted bin-related measures were more important than information provided on bins. This could be a clear indication that members of both schools experience worse waste separation possibilities as compared to other TUM members. Another reasoning behind this tendency could be a stronger sense of relevance for members of both schools towards educational measures.

The comparison of on-campus measures (A, B, C and D) with improved waste collection (E) could not reveal any significant correlations. There is nevertheless the barely insignificant trend that older people and alumni weight improved garbage collection as more important than younger or active TUM members. This could be explained by their intermittent presence at TUM, and hence a lower level of inconvenience from poor waste separation possibilities.

## 3.5. Additional qualitative results in support of quantitative findings

The results reveal a high awareness among TUM members regarding their willingness to separate waste and awareness of waste separation as an environmental problem. Waste separation is largely seen as a practice with benefits for the environment, and hence understood as a responsibility on the personal level. This is supported by the finding that it is largely accepted to spend additional time searching for an appropriate waste bin, instead of just using a mixed trash bin. Waste separation is, however, not always possible for all waste categories. In particular, biological wastes and plastic-metal composites are not disposed of properly. This lack of waste separation is mostly to be attributed to a lack of multi-purpose bins. Only mixed trash bins are readily available among most facilities of TUM. This finding goes hand in hand with a lack of knowledge of any trash bin related color scheme at TUM.

Qualitative feedback on issues regarding waste separation provide additional insights to the quantitative information described above. Concerns regarding the inconsistency in placement of trash bins was raised. To elaborate this further, it was reported that there are multi-purpose bins only in the common areas of many buildings, while no waste separation opportunity persists in office spaces. In most cases, there seems to be only a paper bin and a mixed-waste bin provided in offices. Some employees came up with creative solutions to ensure proper waste separation in these cases, with some of the employees even setting up their own waste separation system. The reported lack in multi-purpose bins goes hand in hand with a lack of trust regarding the waste collection after disposal by the personnel. There is general concern that trash is re-mixed, even if separated by the TUM members. Further criticism concerns special waste categories. Specific types of waste, such as hazardous wastes, electronic waste, wood waste and bulky waste, do not have any uniform disposal system across campuses of TUM.

There is a general consensus among TUM members regarding the need for more efforts to reduce waste. In an effort to reduce waste on campus, various suggestions were gathered via an open guestion. Suggestions include the implementation of additional organic waste bins and the introduction of multi-purpose and special use bins in central locations and offices. It was also suggested that packaging waste from food establishments could be reduced, e.g. by promoting the use of reusable containers or other packaging options. Reusable coffee containers are mentioned here, most likely since they are common in some but not all campuses of TUM. Excessive packaging is also reported for cafeterias. A transition to digital processes in the working space could further reduce waste, e.g. by digitizing printed forms to reduce paper waste. A high amount of avoidable paper waste seems to accumulate in libraries, where more digital solutions might be adopted. Bathrooms were named as a further source of paper waste, which could easily be reduced if hand dryers were to be installed.

## 3.5. Limitations

The survey conducted demanded proper answers from respondents in order to get consistent data, especially regarding the AHP ranking task. Consistent decisions require a relatively high cognitive performance by the participants. Information on the current consistency ratio or a thorough introduction into the methodology are hence often applied in research. It was expected that the maximum time spent on a survey on waste separation should not exceed five minutes. Therefore, a short survey was considered key for this study. The introduction to the AHP task was therefore kept as short as possible. This could explain why a linear scaling of the preference weights led to relatively high inconsistency.

Sample size puts a further limitation to our study. Some smaller campuses had to be aggregated. More differences between campuses may exist and could be elicited with a larger sample size.

### 4. Summary and Future Goals

Our survey highlighted the discrepancy between acceptance of waste separation behavior and actual behavior across various TUM campuses. We find that TUM members are willing to separate waste, but are not able to do so to a large extent. This is most likely due to the lack of multi-purpose trash bins. Unfortunately, only mixed bins, and for a large part also paper bins, are available in everyday campus life. TUM members are furthermore not aware of TUM-wide waste bin color schemes.

While some differences between campuses exist, especially regarding the acceptance of different waste improvement measures, there seems to be a general lack of multi-purpose waste bins across all campuses. The so called "Wertstoffinseln" are not working and should be reconsidered if increased waste separation at TUM was their main motivation.

Better collection of separated waste turned out to be the most requested measure, indicating a lack of trust in the current waste management system. We also observe that information and awareness campaigns are of lower importance in general, but also on the level of campuses (Straubing) or Schools (Engineering and Management).

A high acceptance of the practice of waste separation among TUM members was revealed. Some members are even separating

waste if the respective bins are not present, or if there is a suspicion that waste is mixed during collection. We argue that waste separation is not an information or cultural problem, but an issue of management. Information campaigns would likely be of low effect, especially as long as the number of multi-purpose bins does not increase. Be it the working space, hallways or open spaces, the next convenient bin is the one most likely to be used. We further argue that the second most important measure, after the provision of multi-purpose instead of mixed bins, would be an improvement in waste collection. Waste separation has to be a standard for all sub-contracting firms. Communicating how waste is disposed of in a separated form would further help to build trust between TUM members and subcontractors.

Mere information campaigns on how to separate waste, or on the importance of waste separation, do not hold much promise; low acceptance of waste separation is a problem from the past. The encouraging message is that this is not a people's problem, but a problem of management and infrastructure.

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## Self-reflection

Team 'Role Model' initially started out with 12 passionate students from very different disciplines – sustainable resource management, medicine, health science, agriculture, biochemistry, engineering and education. After a few discussions at the first weekend seminar at the botanical gardens, we soon realized that our common interests lay in sustainability. Sustainability is not an easy theme to start with. Each team member had their own interpretation of the word and this led to inconclusive team meetings and dissatisfied team members. Over the course of a few months, our team numbers halved as several members of the team had to pull out due to various circumstances. We then narrowed down the topic to focus on the different interpretations of the word that people might have and team 'SustainAct' emerged. Our topic was still too vague, however, and eventually our team was dissolved in August 2022 due to conflicts of interest.

In November 2022, team SustainAct reemerged with three members. Our new topic materialized out of the previous discussions of our former team. Waste separation was always a topic of interest for our group due to its high relevance to everyday life and we decided to pursue it further and to investigate within the confines of TUM campuses.

Although we were behind schedule, we re-motivated ourselves and began to design a survey on waste separation behavior at TUM. Fortunately, the response to the survey was very positive, giving us a relatively large data set to analyze. We were able to derive some impressive results from our data, so in the end we were quite pleased with the final outcome. Despite working productively and keeping to our strict schedule, our biggest challenge was running out of time. Looking back, it was a very stressful time, as the entire workload had to be handled by only three people. Fortunately, we were able to successfully complete the project on time and with a remarkably good team atmosphere that was driven by our enthusiasm for the subject.

All in all, we can conclude that we learned a lot from our time at TUMJA, both for our professional and personal development. When we started the project, we had no idea what an incredible journey lay ahead of us. Despite the eventful course of the project with its numerous obstacles, we managed to complete it successfully.

At this point, we would like to thank our tutors Veronika and Rodrigo, who have steadfastly accompanied us throughout the last 20 months. We would like especially to emphasize their constant availability and constructive support. They did not just support us with our topic, but they also helped us hold the team together through to the end.

We would like to thank our former supervisor, Prof. Dr. Cathleen Zeymer, for her enthusiasm for TUMJA and for her continuous support and constructive feedback.

Finally, we would like to thank TUMJA for this great experience that brought us together from different backgrounds. The encouragement and constant inspiration motivated us to embark on this beautiful journey and achieve our goals.



## SustainAct SustainAct Waste separation behavior at TUM **RESEARCH BACKGROUND** Waste management is not uniform across TUM, seen in varying availability of trash bins, which allow sorting. While some offices are equipped \*\*\*\*\*\*\* with trash bins for paper and one mixed bin, there are several offices with mixed-purpose trash bins only. Similar observations can be drawn from public spaces. Campus buildings are mostly equipped with mixed-purpose bins, while multi-purpose bins are rare. nings in the availability of multi-purpose trash bins, espe The shortcon cially at WZW Campus in Freising, has drawn the attention of TUMs Green Offices. Campaigns, which aim at improving waste separation, are planned for the year 2023. **RESEARCH QUESTION** BATA COLLECTIO Our first research question aims at the current status quo of waste separation at TUM, taking into account the large variability in available waste separation possibilities.

## >>> To what degree is waste separated at different TUM campuses?

Interventions at various TUM campuses are planned to improve waste separation. Our second research question aims at different improvement strategies and their benefits.

## >>> Which measures should be introduced to improve waste separation?



## TIMELINE AND PROJECT PLAN



#### METHODOLOGY

The research questions are tackled via a guantitative survey aimed at TUM students and employees of different campuses and study fields. The survey follows the analytic hierarchy process (AHP) framework to reveal the relative preference for different benefits of a campaign on trash separation. The compositional data is analyzed by compositional data analysis. Regressions will be run to determine factors that explain the relative importance of diff



## POSTER 3:

ПΠ

Right from the beginning of the program, our team wanted to collaborate on a topic related to sustainability. Sustainability being a very broad theme, we quickly had to narrow this down quite drastically. Waste separation had always been one of the recurring topics in our discussions. After talking with representatives from the Green Office in Weihenstephan, we eventually decided to look into the waste separation behavior at various campuses of TUM. The lack of uniformity in waste separation opportunities sparked our interest and we wanted to look into its current status-guo. The Green Office plans to implement various measures to improve waste separation behavior TUM-wide, and we wanted to inquire of students and employees what they thought would be of most benefit. Our research questions were thus condensed down to: To what degree is waste separated at different TUM campuses? and Which measures should be introduced to improve waste separation? In order to investigate these questions, we decided to conduct an online survey aimed at students and employees of TUM following the analytic hierarchy process (AHP) framework to reveal the relative preferences for different benefits of a campaign on trash segregation. Our project started in November 2022 and we managed to gather data by mid-March 2023 to conduct the mentioned analysis in April 2023. 

TUTORS

## POSTER 4:

пп

TUM students and employees, and we analyzed the data using two methods: the analytical hierarchy process (AHP) and compositional data analysis (CDA). CDA helped us understand the current state of waste separation behavior at TUM, while AHP was used to evaluate different measures for

improving waste separation.

Our survey revealed a gap between the acceptance and actual practice of waste separation at TUM campuses. Limited availability of multi-purpose waste bins and a lack of awareness about waste bin color schemes contribute to the challenges faced by TUM members. The existing "Wertstoffinseln" stations are ineffective in promoting waste separation. Improved collection of separated waste is crucial, so this ineffectiveness indicates deficiencies in the current waste management system. Information and awareness campaigns are considered less important overall and at specific campus or school levels. Addressing these issues is vital for promoting effective waste separation practices at TUM.

We gathered approximately 170 responses from

In collaboration with the facility management, the Green Office has implemented the first measure, which is an organized color scheme for proper waste separation. Low acceptance of waste separation is a problem of the past. We encourage further measures to be implemented in the future, aligning sustainability with excellence.



#### **RESEARCH BACKGROUND**

Environmental concern and awareness of proper waste treatment is generally attributed to the academic environment. In our project **SustainAct**, we tried to find out whether TUM can actually be attributed a pioneering role in waste separation. To this end, we conducted an online survey among TUM students, staff and alumni to ascertain the current status of waste separation and to investigate potential for improvement. The results show that there is a strong awareness tor waste separation, but that the possibilities for correct separation on site are not always given, which indicates potential for control separation. Recommendations for promising measures are given, emphasizing the importance of a TUM-wide approach.

#### **RESEARCH LIFE CYCLE**



#### **CONCRETE RESULTS/OUTCOME**

Our survey highlighted the discrepancy between acceptance of waste separation behavior and actual behavior across various TUM campuses. We find that TUM members are willing to separate wasts, but are not able to do so to a large extend. This is most likely due to the lack of multi-purpose traft bins. Unfortunately, only mixed bins, and for a large part also papers bins, are available in everyday campositile. TUM members are furthermore not avance of TUM wide waste bins color schemes.

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OUR TEAM

TUTORS

Asstha Chandiwala, Moritz Ptacek, Corinna Winkler Contact: sustainact@ja.tum.de Veronika A. Bauer, Rodrigo de Rojas Prof. Dr. Niklas Boers, Prof. Dr. cathleen Zeymer The so called Wertstoffinseln are not working and should be reconsidered if increased waste separation at TUM was their main motivation.

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#### IMPACT/SUSTAINABILITY

A high acceptance for waste separation among TUM members was revealed. Some members are even separating waste if the respective bins are not present, or if there is a suspicion that waste is mixed during collection. We argue that waste separation is not an information problem, but an issue on the level of management. Information campaigns would likely be oflow effect, egocially as long as the number of multipurpose bins does not increase. Be it the working space, hallways or open spaces, the next bin is the most likely one to be used. We threfther argue that the second most important measure, after implementation of multi-purpose instead of mixed bins, would be an improvement in waste collection. Waste separation has to be a standard for all sub-contracting bers and subcontractors. Mere information campaigns on how to separate waste, or on the importance of waste separation, do not hold much promine.

Low acceptance of waste separation is a problem from the past. The encouraging message is that this is not a people's problem, but a problem of management and infrastructure.

#### >> PROJECT PARTNERS/STAKEHOLDERS

Stakeholders: Students, employees, alumni of TUM; Waste management of TUM

Partners - Green Office Weihenstephan, Facility Management

#### >> ACKNOWLEDGMENTS

We would like to thank our tutors Veronika A. Bauer and Rodrigo de Rojas for their constant support during our project. We would also like to express our graftbute towards the TUMJA office, especially Peter Finger and also the Green Office WZW. We also thank Hoang Tien Vo for his methodological ideas and support and Prof. Dr. Cathleen Zeymer for heiging us distribute our questionnaire.



inspired by



## Project Report VINFO

We investigated the language and rhetoric used by alternative media channels affiliated with the Querdenken movement in Germany during the COVID-19 pandemic. With our results we hope to contribute combating the spread of disinformation, increase public trust in evidence-based public health measures, and foster informed decision-making.

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## Preface by the Supervisors Dr. Eleni Georganta and Dr. Kristina Schick

Understanding how misinformation is created is particularly relevant in today's digital age where information can spread rapidly and widely, having significant impact on individuals, communities, and societies. Our group Team VINFO decided to explore this topic and empirically investigate the language and discourse utilized by the German anti-COVID movement "Querdenken." Based on the misleading information spread during the COV-ID pandemic, they focused on the representation of the German anti-COVID movement Querdenken in their prominent news sites and online blogs. Their empirical evidence can provide insights into how conspiracy theories and misinformation spread, making suggestions to help individuals become more critical consumers of information, identify and counteract false or misleading claims, and ultimately make more informed decisions.

Team VINFO has decided to use mixed methodology and investigate which linguistic features and strategies are used by Querdenken media and which evidence is brought into the discourse when reporting their perspective on the pandemic. Using a quantitative approach, they first performed a systematic quantitative analysis to explore the extent to which scientific terminology was used in Querdenken media. Second, applying a qualitative analysis, they evaluated how evidence was used to support the movement's claims.

As supervisors, we had the privilege of guiding this interdisciplinary group of young students who were highly motivated, committed and self-organized. Supervising this group was a great experience and all of us learned a lot from this project.





## Supervisor insights

For me, **Eleni Georganta**, as a team researcher, it was an absolute delight to supervise a group of such motivated young students. Right from the beginning of the project, they showed great inspiration and determination, and their enthusiasm never dwindled throughout. Watching them grow both academically and as individuals was very rewarding. It was inspiring to see them put in so much effort towards their research, and seeing their hard work pay off, especially with the acceptance of presenting their findings at an international conference.

## What is your research interest or motivation for science?

My research interest is centered on understanding the dynamics that emerge within teams. Whether it's conflict, innovative ideas, or motivation among individuals who don't know each other, my aim is to identify the essential mechanisms that promote successful and effective collaboration. I believe that all team members can grow when these mechanisms are in place, and my research focuses on using evidence-based approaches to shape the future of teamwork for organizations.

## What special experience from your studies/career would you like to share with the scholars?

Good research is only possible if you are passionate about the questions you are seeking to answer. It's essential to keep exploring and investigating the phenomena that you find most intriguing. Challenges and obstacles may arise, but every experience is an opportunity to learn and grow. Embrace the difficulties and always push yourself to overcome them. Remember that research is about discovering something new and contributing to the field, so always strive to ask and answer the questions that matter most to you.

## **Supervisor insights**

I can only agree with Eleni. It was a great pleasure for me, **Kristina Schick**, to experience the spirit and the great commitment of the group to the topic in particular and to answering scientific questions in general. The work of the group was characterized by a great independence and a passion for knowledge which is second to none. Their project results, especially the opportunity to present their findings to the scientific community beyond the TUMJA community, are the fruits of their work over the past two years.

### What is your research interest or motivation for science?

My research interest is to foster medical communication skills. With my research, I would like to contribute to the long-term improvement of medical care and to gain insights into how communicative competencies can be further fostered and improved in the long term. For this purpose, I use different methods and concepts: On the one hand, I investigate how attitudes affect performance in patient conversations and how different learning settings, like simulation and workplace learning, can affect competence development.

## What special experience from your studies/career would you like to share with the scholars?

In the research I have done on the issues of doctor-patient communication and professional identity formation, I have seen over and over again how important it is to speak the same language and what difficulties arise when people do not understand each other or do not want to understand each other. With your work, you contribute to reducing the communication gap with the Querdenken community and to raise awareness of the importance of phrasing and its interpretation.

## This Title Can Manipulate You

"This vaccination must be an IQ test. You can bring arguments as you want, it's like talking to a wall ... unbelievable." This paragraph, written by a user named Juliane, can be found in the comments column of the website "corona-blog.net," which describes itself as "news from citizens for citizens." The author continues: "In any case, no one who has had the stuff given to them needs to whine all over me about any damage. If you're too lazy or too stupid to do the research, you'll just have to live with it."

The specific article that provoked this reaction is about SM-102: an ingredient of the Moderna vaccine, which, according to the subheading, can allegedly pose a risk to fertility and unborn children, and is also carcinogenic. Juliane is not the only one to vent her anger in the comments about this: while Christiane simply demands that the "pharmaceutical giants should be sued," Isabel suspects that the vaccine will make cells glow in order to "[...] scan people with it, for example at the airport or in the shopping mall." Birk, under another article referencing alleged deaths connected to mRNA vaccines, refers to biblical sources instead of his own thoughts:

"[...] To all politicians who present these deadly vaccinations as good, let this be said: 'Woe to those who call evil good and good evil, who put darkness for light and light for darkness, who put bitter for sweet and sweet for bitter!' (Isaiah 5:20)."

Emotions are running high. But why? What dark secrets has the "Corona Blog" revealed about the pharmaceutical industry? If you look at the content of the article, you will find one main source for the claim that the substance SM-102 is supposed to be toxic: A safety data sheet from Cayman Chemicals. The article points out that the following warning can be found there: "For research purposes only, not for human or veterinary use." As a layman, this is enough to send shivers down your spine, as a chemical whose use in humans is explicitly prohibited here is being added to a widely administered vaccine. In addition, according to the safety instructions, this chemical is said to be carcinogenic, teratogenic

and toxic to the liver – the list is long and threatening. However, if you look at the document with a bit of background knowledge, you will see that the dangers do not come from the substance SM-102 at all, but from the solvent, more precisely chloroform, in which it is dissolved. Apart from the fact that chloroform is a solvent and therefore not present in the final vaccine, it is not even explicitly mentioned that this SM-102 chloroform solution is used to manufacture the Moderna vaccine. These are several small but very important differences, but they reveal the central claim of this article to be based on misunderstanding. So how can we explain the fact that many readers react in such an outraged way to the article's "revelations," even though they are not revelations at all?

Part of this can probably be attributed to the blog's position as part of the "alternative media." These mostly see themselves as a corrective to the mainstream media and thus attract readerships that are highly suspicious of it. Linked to this is the phenomenon of confirmation bias, which describes a tendency to value information as correct if it reinforces existing positions. Since a dislike of vaccines led most Corona Blog readers to seek out the website in the first place, they will also be more willing to acknowledge its alleged revelations as such. Another such cognitive bias is the Dunning-Kruger effect, a phenomenon in which people with low skills, expertise, or experience in a particular type of task or area of knowledge tend to overestimate their competence or abilities. In this case, ignorance and superficial knowledge regarding vaccines leads both the author and the readers to falsely see themselves as experts in the field and, as a result of this distorted perception, to express themselves as such. In the words of Juliane, "If you're too lazy or too stupid to do the research, you'll just have to live with it."

The language of the text can also be a major factor influencing the apparent credibility and persuasiveness of the "Corona Blog." After all, how a statement is received depends not only on the content, but also – and to the same, if not greater, extent – on the way it is conveyed. Language is, as Wilhelm von Humboldt said, the "ultimate medium of thinking and of one's world view." The list of things we can use language for is endless. Among other things, we can use language to communicate our thinking and world view to others, but we can also use language to influence, or worse, manipulate the thinking and world view of others.

The ways in which language can be shaped take a variety of forms. For example, so-called "othering," a creation of group identities, aims to antagonize vaccination advocates: "Us" versus "them". This, combined with an emotionally charged vocabulary that is negative in tone and at the same time enriched with technical terms from science, creates an almost culinary harmony: The bitter outrage is made palatable to the reader by the sweet and multifaceted taste of scientific legitimacy, which docks directly onto the Dunning-Kruger taste buds. Such rhetorical morsels frequently appear within the text of the Corona Blog, as exemplified in the following paragraph, which attempts to put the article's alleged revelations into perspective:

"In view of these points, one can only be speechless. Does anyone really still believe that the Corona vaccination is about health? Why inject millions of healthy people with such poison – without even being able to guess at the long-term effects?"

The fact that these linguistic devices often occur in texts from alternative media such as the Corona Blog is not merely an assumption, as our research project shows. We were able to prove quantitatively that language with both an emotive tone and peppered with scientific terms is used significantly more often here than in established media. But the question still remains: Do these scientific statements have any substance, or are they ultimately just smoke and mirrors intended to cloud the reader's view? We have examined this on a random basis for 40 other articles to get an overview of how often sources are misrepresented. Language, as the foundation of our communication, is omnipresent and its influence is enormous. If linguistic means are used skillfully, a text can carry a very high power of persuasion or manipulation. Of course, this influence of language comes with dangers, which can be seen in propaganda, among other things. Enemy images can quickly arise from othering, which often leads to racism and discrimination. The influence of language on our opinion is not something bad per se, we just have to be aware of the dangers to be able to prevent them. At the same time, we can create something good by strengthening communication in the right places and making it more persuasive, for example in the mediation and resolution of conflicts or in the field of science communication. Then, in the end, everyone would be a little smarter and the misunderstandings reported at the beginning of this text would not have arisen in the first place.

What would be the link to Juliane now? Let's try to see the world from her point of view: Frustrated by the Corona policy of the German government, she looks on the internet for alternatives to mainstream media, which she doesn't trust anymore. There, she comes across an article that not only reinforces her skepticism about mRNA vaccines (keyword: confirmation bias), but also expresses a dissatisfaction about the status quo that one cannot find in "conventional" media. At the same time, a rhetorical aura of scientific seriousness hangs over the text, elevating it above the level of contentless polemics and leaving her with the feeling that she might be onto something big. It seems that if you understand these distinctly human mechanisms that make you susceptible to dubious information, it is easier to understand the thought processes of the people that fall victim to it. After all, these mechanisms are universal: No one is free of cognitive distortions, and no one can claim to see the world objectively and free of judgment. A small part of Juliane is in each of us – perhaps we should be aware of this so that we notice early enough before it comes to the surface.

## Decoding the discourse

## Abstract

This study investigates the language and rhetoric used by alternative media outlets affiliated with the Querdenken movement in Germany during the COVID-19 pandemic. We analyzed articles from Querdenken, tabloid, and newspaper outlets using dictionary-based analyses to examine emotional tone, health-related language, and usage of scientific terminology. Further, we conducted a qualitative analysis to assess the originality and congruence of sources cited. Results show that Querdenken outlets use a more scientific language, exhibit a more negative emotional tone, and have a higher usage of health-related language compared to other outlets. Additionally, we found a significant mismatch between sources and claims in the interpretation of information. Our study highlights the important role of alternative media in shaping public discourse and opinion and emphasizes the need for improved communication of scientific information and regulation of alternative media outlets.

## Introduction

The COVID-19 pandemic has been and continues to be one of the biggest challenges our world has faced in recent memory. At the time of writing, over 760 million confirmed cases and over 6.9 million deaths have been reported to WHO (World Health Organization, 2023). While its impacts seem to be predominantly health-related, its societal effects should not be overlooked. The toll that prevention measures such as lockdowns or school closings took on the economic and social life of many citizens led to them voicing their concerns and displeasures about their situation in various ways, be it on the street or on conventional and social media (Douglas, 2021). One group that emerged out of this growing discomfort is the so-called "Querdenken" movement, a loosely organized German-speaking collective made up of people from all sociological and political walks of life whose attitudes range from skepticism to extremism and radicalism (Marko, 2022). They are united by their concern about governmental and pharmaceutical interventions meant to curb the spread of the pandemic (Nachtwey et al., 2020). It is this movement that sparked controversy through actions such as demonstrative "strolls" through cities during lockdown (Finkbeiner, 2022), the formation of a political party ("DieBasis") explicitly positioned in opposition to COVID-19 measures (Niedermayer, 2023), and their fervent activism and vaccine skepticism online.

For many movements that claim to be opposed to the mainstream, alternative media plays an important role. Alternative media serves as a "self-perceived corrective" (Holt et al., 2019) to what is seen as the current political or journalistic mainstream. This is hardly a clear-cut distinction, as there exists an overlap between the worlds of alternative and mainstream media (Harcup, 2005), but it does serve as an important descriptor of a collection of news sources that cater to those with serious distrust of mainstream organizations. Members of the Querdenken community can be described as such (Nachtwey et al., 2020). This distrust creates a demand for alternative COVID-19 narratives, leading to widespread proliferation of online outlets within Querdenken groups. These outlets are used as sources of evidence for claims on vaccine efficacy, virus danger, and adverse effects of measures. We want to examine these outlets to understand their communication methods and the use of outside sources to legitimize their views.

There is widespread concern about a rising prevalence of disinformation (Sousa-Silva, 2022), something the World Health Organization has coined the "infodemic" (World Health Organization, 2020) - a perception that has led to an increase in research on the topic. Especially now in the context of the COVID-19 pandemic, disinformation such as conspiracy theories thrives more and more as people feel threatened, uncertain, and insecure (Douglas, 2021). Alternative media has been identified as a frequent source of disinformation (Frischlich et al., 2020; Grinberg et al., 2019) and existing research has examined its organizational dimensions (Figenschou & Ihlebæk, 2019; Harcup, 2005) as well as its content (Haller & Holt, 2019; Nygaard, 2019). Since conspiratorial thinking is well established within the Querdenken community (Nachtwey et al., 2020), it is also worth mentioning the similar body of research pertaining to conspiracy theories and theorists (Douglas et al., 2019; Douglas & Sutton, 2018; Fong et al., 2021). Within these studies, it has been discovered that even brief exposure to conspiratorial content can have concerning effects, such as lower social and civic engagement and a greater likelihood of engaging in science rejection (Jolley & Douglas, 2014; Lewandowsky et al., 2013; Lewandowsky & Oberauer, 2016; van der Linden, 2015). Therefore, it is urgent to analyze them more closely to find ways to counter them effectively (Sunstein & Vermeule, 2009). It is important to note that most of this research addresses anglophone communities. A major difference between German- and English-speaking anti-mainstream movements seems to be a strong predisposition to right-wing populism in English communities (Kerr & Wilson, 2021) that is not as present in the Querdenken movement, as most of their members report having voted for left-liberal parties in the last Bundestag election before the pandemic (Nachtwey et al., 2020). Thus, this movement seems to have certain unique attributes that warrant a specific analysis of its properties.

Existing research has mainly employed content analysis (Boberg et al., 2020; Quandt et al., 2020). However, not only the content, but also how it is conveyed, more precisely the language of the Querdenken movement, should be examined in more detail. Drawing on the framework of Critical Discourse Analysis (CDA), which underlines the role of language in the construction of knowledge and societal norms (Baker & McGlashan, 2020), we want to concentrate on the language used within alternative media outlets that are used to support Querdenken arguments. Past linguistic examinations of this ecosystem have been relatively small-scale and/or have focused more on the language of readers than on the outlets themselves (Douglas & Sutton, 2018; Marko, 2022; Thiele, 2022; Zollo et al., 2015).

In a qualitative analysis, Marko found that in a COVID-19 conspiracy group, linguistic features that are typical for extremist groups, such as ideological in-group and out-group presentation and the agentless passive voice which aims to evoke fear, are used. Other linguistic techniques include the misrepresentation of scientific knowledge and the use of colloquial language, among other things, to establish a connection between members of the group and to distance themselves from the government and the rest of the population, whom they perceive as enemies and oppressors.

In this study, connecting this previous, qualitative work with computational methods, we wish to answer two research questions: Which linguistic features and strategies are used by Querdenken media in the discourse to legitimize their views on the pandemic? Which evidence is brought into the discourse when reporting on their perspective on the pandemic? To examine the language of alternative media outlets connected to Querdenken (henceforth referred to as "Querdenken media"), we performed a dictionary-based analysis of their language on a dataset of 25,934 articles using a proprietary dictionary for scientific terms as well as the Linguistic Inquiry and Word Count dictionary (LIWC) (Pennebaker et al., 1999) to examine emotional tone and, as a completely novel approach, scientificity of language, respectively, in comparison to datasets of mainstream news and tabloid news (3,241 articles in total). Furthermore, we conducted a case study on a small subset of our Querdenken media articles to examine their usage of sources qualitatively.

## **Methods**

## Data

Data were gathered for three different media sets: mainstream media, science journalism publications, and outlets connected to Querdenken. To create the Querdenken media set, a web scraper was used to crawl the websites of Report24, Uncut-News, Rubikon, Transition News, and Corona Blog, and capture all pertinent data, including the title, author, publication date, and complete text of each item. The generated dataset consists of 25,934 articles with a relationship to COVID-19, the Querdenken movement, or a far-right online news network in Germany. These articles are either directly or indirectly related to COVID-19. This was accomplished by including articles that were unmistakably about COVID-19, like those from Corona-Blog, those having the words "corona," "pandemic," or "COVID.19 pandemic.

For the mainstream media sample, two outlets were included, Der Tagesspiegel and Bild, which were scraped using the academic access to LexisNexis. A constructed week sampling approach was utilized to select a sample of articles from March 2020 to December 2021 for both publications. Constructed week sampling is a widely used sampling technique in content analysis, which involves the creation of a random sample of weeks over a given time period (Luke et al., 2011). The resulting dataset, which is based on the same filtering method as described in the preceding paragraph, consists of 3,241 newspaper and tabloid items that were either directly or indirectly related to the COVID-19 pandemic in Germany.

Zeit Wissen and Spektrum der Wissenschaft are the two science journalism publications that were used in this study. Zeit Wissen is a popular science publication in Germany that focuses on subjects like technology, medicine, and the natural world. In contrast, Spektrum der Wissenschaft is a monthly magazine that covers recent advances in science and technology. Its 12,000-page sample spans the years 2008 through 2022. No additional filtering was done on the scraped articles because the main goal of this sample is to create a frequency table for scientific terminology.

## **Ethical Considerations**

This research project addressed ethical considerations regarding the sensitivity of the available data. To prevent the spread of potentially harmful information, we decided not to make the dataset publicly available. In addition, we avoided disclosing any detailed identifying information to safeguard the identity and privacy of the people featured in the publications.

## Methodology

## **Dictionary Creation**

A dictionary was designed for a systematic and quantitative analysis of scientific language used by Querdenken media, and to provide insight into the extent to which they use scientific terminology in their discourse.

In doing this, the words included in the dictionary were obtained from word frequency tables of articles from the field of science journalism taken from samples of the media Spektrum der Wissenschaft and Zeit Wissen. All words in our sample with a frequency greater than 100 were evaluated independently by five judges and classified into one of the following categories or rejected: (1) professions and institutions associated with sciences, (2) research-related terms, (3) life sciences terminology, and (4) terminology from other sciences. The five judges reviewed the lists they had compiled for each publication together and eliminated any duplicate submissions. The final result was a joint dictionary combining the lists from both publications.

### Quantitative Analysis

In this study, we conducted a quantitative analysis of the language used in the COVID-19-related articles collected from five Querdenken-affiliated websites (Report24, Uncut-News, Rubikon, Transition News, and Corona Blog), as well as articles from a newspaper (Der Tagesspiegel) and a tabloid (Bild), spanning from March 2020 to December 2021.

Given that the number of articles per month varied across the different media outlets, we decided to average the values of LIWC and dictionary categories per month and outlet type (Querdenken media, tabloid, and newspaper). We then performed statistical analyses using linear mixed models with fixed effects for the month, the publication type (tabloid, newspaper, Querdenken outlet), and the random effect for an outlet (Uncut-News, Corona Blog, Rubikon, Tagesspiegel, Bild, etc.) for the LIWC categories and our self-developed dictionary categories. Post hoc, we also computed contrasts (ANOVAs) to clarify the differences between the publication types, independent of the temporal trend.

### Qualitative Analysis

Furthermore, a qualitative analysis of the claims made by Querdenken media outlets (Corona-Blog, Report24, Rubikon, Transition News, and Uncut-News) was conducted to evaluate how cited sources were used to support the movement's claims. To ensure a sufficient degree of objectivity, a codebook consisting of five categories and providing instructions for the evaluation process was created. A minimum of 50 claims was analyzed for each Querdenken medium, including 50 claims from Corona-Blog, 51 claims from Report24 and Rubikon, 50 claims from Transition News, and 52 claims from Uncut-News.

Articles were chosen from the Querdenken media dataset for study by the assessors using a random number generator. Only articles with a connection to COVID-19 or SARS-CoV-2 were included. Articles with the following focus were excluded: letters to the editor, excerpts from discussion forums, interviews, or articles that linked exclusively to a video. This ensured that the cited sources were analyzed in the context of the author's argumentation.

All article claims were listed and numbered consecutively. A maximum of ten claims per article was analyzed. If the number of claims was greater than 10, ten claims were randomly selected from the article to avoid bias. Each claim was evaluated based on three criteria: whether it was a translation or copy of an existing article, whether sources were cited, and whether the sources were freely available without any restrictions like a paywall or subscription. When a claim had a source, that source was examined, and if the material cited any other references, those references were examined as well. The last reference accessible in this chain of citations was used as the main source for the qualitative analysis. Five criteria were used to determine source-citation congruence: whether the article and source's content were linked (topic), whether there was a logical link between the article and source (logic), whether all relevant information was taken from the source (leave), whether no non-source content was added (add), and whether the information from the source was interpreted correctly in the sense of the author of the source (interpretation).

Throughout the analysis, the assessors took notes on the article and the source in a separate document to justify their evaluations. This approach ensured a rigorous and systematic evaluation of the claims made by Querdenken media outlets, providing valuable insights into the use of evidence in the movement's discourse on the pandemic.

For the qualitative analysis of the claims made by Querdenken media outlets, descriptive statistics were displayed for the different categories per outlet and in total. The five categories used to evaluate the source-citation congruence included topic, logic, leave, add, and interpretation. Furthermore, data on degrees of separation, whether a source was given for the claim, and the type of source (article, blog, governmental source, etc.) were also collected.

### Measures

In this study, we employed a self-developed dictionary for the German language to measure the use of scientific language in texts, which we believe is a novel approach to understanding the discourse surrounding the COVID-19 pandemic. This approach is particularly relevant, as previous research suggests that Querdenken-affiliated media may use pseudo-scientific statements to support their perspectives on the pandemic, positioning themselves as enlightened, while characterizing those who disagree with them as blindly following the mainstream narrative (Marko, 2022).

Our dictionary consists of four categories: (1) professions and institutions associated with sciences, (2) research-related terms, (3) life sciences terminology, and (4) terminology from other sciences. To compute the values for each of these categories, we used the Linguistic Inquiry and Word Count (LIWC) software to analyze each article in our dataset of science journalism media, to be named Spektrum der Wissenschaft and Zeit Wissen. The number of entries per category and examples from each can be found in Table 1.

Category	Number of entries	Examples
Professions and institutions associated with sciences	28	"biologen," "dr.," "forschungsinstitute"
Research-related terms	68	"analyze," "beweis," "experiment"
Life sciences terminology	93	"dna," "enzym" "immunsystem"
Terminology from other sciences	53	"atom," "exoplaneten," "frequenz"

Table 1: Number of entries per category and examples

To assess the internal consistency of each of our self-developed dictionaries, we used a subset of our science journalism sample dataset containing around 3,000 pages not used for the dictionary creation. We calculated both Cronbach's alpha and the Kuder-Richardson Formula 20 (KR-20) for each dictionary category. Each word included in the lexicon was measured as a percentage of total words per text (Cronbach's  $\alpha$ ) or, alternatively, in a binary "present versus absent" manner (Kuder-Richardson Formula 20; Kuder & Richardson, 1937). The raw, unstandardized Cronbach's alpha and KR-20 values for each dictionary category are presented in Table 2.

It is important to note that the traditional Cronbach's alpha method, calculated from relative word frequencies, tends to underestimate reliability in language categories due to the highly variable base rates of word usage within any given category, which may explain the moderate to high but not perfect values for Cronbach's alpha observed in some categories (Pennebaker et al., 2007). However, the Kuder-Richardson Formula 20 is generally considered a better approximation of each category's true internal consistency and reports a value close to 1 for the life sciences terms and research-related terms categories, indicating a very high internal consistency. The professions and other sciences terminology categories also

showed acceptable internal consistency with KR-20 values of 0.32 and 0.66, respectively. The Cronbach's alpha values were moderate to high for all categories, ranging from 0.52 to 0.87.

## LIWC

The Linguistic Inquiry and Word Count (LIWC; Boyd et al., 2022; Pennebaker et al., 2007) is one of the most widely used computational methods to convert text to psychological constructs. LIWC is a text analysis program consisting of over 80 dictionaries for linguistic, psychological, and topical categories indicating various social, cognitive, and affective processes (for a comprehensive list of the dictionaries, see Table 1 in Pennebaker et al., 2007). To analyze a text, LIWC calculates the percentage of words in the text that match a dictionary word, out of the total number of words in the text. For example, the positive emotion dictionary includes 408 stems such as "amaz\*", "excit\*", etc. In a six-word text "I love going to the dentist," the output by LIWC is 16.6% for the positive emotion dictionary (i.e. one positive emotion word "love" divided by six total words in the text), 16.6% for the health dictionary (i.e. one health word, "dentist"), and 0% for the negative emotion dictionary. Past empirical studies on the validity of LIWC have found that it is reliably able to detect meaning from text in a wide variety of contexts, as well as detect emotional states, intentions, motivations, thinking styles, and individual differences (Pennebaker et al., 2015). We used the latest available LIWC dictionary for German (LIWC 2015), more specifically we used the categories emotional tone and health, generating values for each article in our sample.

The emotional tone category in LIWC refers to the extent to which language expresses emotions, such as joy, sadness, anger, or anxiety. As a combined dictionary, its value expresses how positive or negative a text's emotional valence is: Texts with a score higher than 50 usually are understood to be more positive in their tone, texts with

a score lower than 50 are understood to be more negative in their emotional tone (Pennebaker et al., 2007). This category is particularly relevant to the study of discourse around the COVID-19 pandemic, as emotions are known to play a significant role in shaping public opinion and attitudes toward health issues (Hase & Engelke, 2022).

The health category in LIWC refers to the use of language related to health and well-being, such as terms related to illness, medication, and medical procedures. In the context of our study, analyzing the health category allows us to examine the extent to which media outlets are focused on discussing the actual health implications of the pandemic. We included this category as an addition to our self-developed dictionary.

## Results

All data and graphics are available in the supplementary material at https://www.ja.tum.de/en/ja/projects/2022/vinfo/.

## **Quantitative Results**

## LIWC: Emotional Tone

We fit a linear mixed-effects model with emotional tone as the response variable, month and type as fixed effects, and outlet as a random effect. The model revealed a significant effect of type on emotional tone, indicating that Querdenken outlets had a significantly lower mean emotional tone (Estimate = -13.388, SE = 4.691, p = 0.0437) than newspapers. No significant effect was found for the month of publication (Estimate = 0.002431, SE = 0.002537, p = 0.3400). The estimate for the effect of outlet type on emotional tone remained significant after adjusting for multiple comparisons using the Tukey method (Querdenken outlets vs. newspapers: z = -2.854, p = 0.00864). In addition, we found a significant difference in mean emotional tone between tabloids and Querdenken outlets (z = 4.830, p = 4.1e-06); only the difference between tabloids

Metric	Professions and in- stitutions associated with science	Research-related terms	Life sciences termi- nology	Terminology from oth- er sciences
Cronbach's Alpha (Raw)	0.52	0.87	0.78	0.53
Kuder-Richardson Formula 20	0.32	0.79	0.84	0.66

Table 2. Internal consistency metrics for each dictionary category

and newspapers (z = 1.534, p = 0.12501) delivered no significant results. All analyses were carried out in R version 3.0.2 using the Ime4 package (version 1.0-5).

The results of the linear mixed-effects model revealed that the emotional tone of articles was significantly predicted by the type of outlet. Specifically, articles published in Querdenken outlets had a significantly more negative tone than articles published in newspapers (b = -13.39, t = -2.85, p < 0.05), while articles published in tabloids had a significantly more positive tone than articles published in newspapers (b = 9.27, t = 1.53, p > 0.05). The month of publication did not significantly predict emotional tone (b = 0.00, t = 0.96, p > 0.05). The strongest predictor of emotional tone was outlet type, with Querdenken outlets consistently exhibiting a more negative tone than the other types of outlets.

## LIWC: Health

The linear mixed-effects model with health as the response variable, month and type as fixed effects, and outlet as a random effect, showed that the type of outlet significantly predicted the mean health score of articles. Specifically, articles published in Querdenken outlets had a significantly higher mean health score than articles published in newspapers (Estimate = 0.00..., SE = 0.00..., p = 0.019), while articles published in tabloids did not significantly differ from those published in newspapers (Estimate = 0.00..., SE = 0.002..., p = 0.643). The strongest predictor of health score was outlet type, with Querdenken outlets consistently exhibiting a higher mean health score than the other types of outlets.

The estimate for the effect of outlet type on the variable of health remained significant after adjusting for multiple comparisons using the Tukey method (Querdenken outlets vs. newspapers: z = 3.818, p = 0.0004). In addition, we found no significant difference in health-related language usage between tabloids and newspapers (z = 0.157, p = 0.4489), while the difference between tabloids and Querdenken outlets was significant (z = -2.847, p = 0.0088). The results of the linear mixed-effects model revealed that there were significant differences in health-related language usage between the types of outlets. Querdenken outlets had a significantly higher mean usage of health-related language than newspapers, while tabloids did not significantly differ from newspapers.

## Dictionary: Professions and Institutions

A linear mixed-effects model was fitted to the data with the dictionary variable for the usage of professions and institutions associated with sciences as the response variable, month and type as fixed effects, and outlet as a random effect. The results show that the number of professions and institutions mentioned in articles was significantly influenced by the month of publication (Estimate = -0.0002... SE = -0.00001..., p = 0.00862), but not by the type of outlet (Querdenken outlets: Estimate = -0.0002... SE = -0.00001..., p = 0.08852; tabloids: Estimate = -0.0007... SE = -0.00001..., p = 0.63386). However, the type of outlet for Querdenken outlets can be seen as approaching significance.

Post-hoc testing using the Tukey method revealed no significant differences in the number of professions and institutions mentioned between newspapers and Querdenken outlets or between newspapers and tabloids. However, the difference between Querdenken outlets and newspapers approached significance (z = 2.232, p = 0.0767). Overall, these findings indicate that the month of publication is a significant predictor of the number of professions or institutions mentioned in articles, but the type of outlet does not have a significant effect.

## Dictionary: Research-Related Terms

We fitted a linear mixed-effects model with research-related terms as the response variable, month and type as fixed effects, and outlet as a random effect. The model revealed a significant effect of type on the use of research-related terms, indicating that Querdenken outlets had significantly higher mean usage of research-related terms (Estimate = 0.252, SE = 0.105, p = 0.0477) than newspapers. Additionally, there was a significant effect of month on the use of research-related terms (Estimate = -0.0001722, SE = 0.0000572, p = 0.0032). No significant difference was found between tabloids and newspapers (Estimate = 0.002298, SE = 0.1349, p = 0.9864). After adjusting for multiple comparisons using the Tukev method, the estimate for the effect of outlet type on the use of research-related terms remained significant (Querdenken outlets vs. newspapers: z = 2.411, p = 0.0477). Moreover, a significant difference in the mean usage of research-related terms was found between tabloids and Querdenken outlets (z = -2.389, p = 0.0477), but no significant difference was found between tabloids and newspapers.

The results of the linear mixed-effects model revealed that the usage of research-related terms in articles was significantly predicted by the type of outlet and the month of publication. Specifically, articles published in Querdenken outlets had significantly higher usage of research-related terms than articles published in newspapers (b = 0.252, t = 2.411, p < 0.05). In contrast, no significant difference was found between articles published in tabloids and newspapers (b = 0.0023, t = 0.017, p > 0.05). The month of publication significantly predicted the usage of research-related terms (b = -0.0001722, t = -3.008, p < 0.01). The strongest predictor of research-related term usage was outlet type, with Querdenken outlets consistently exhibiting a higher usage of research-related terms than the other types of outlets.

## Dictionary: Life Sciences Terminology

The linear mixed-effects model with the usage of life sciences terminology as the response variable, month and type as fixed effects, and outlet as a random effect, showed that neither type of outlet or month significantly predicted their mean usage (p > 0.6).

## Dictionary: Terminology from Other Sciences

The linear mixed-effects model with the usage of terminology from other sciences as the response variable, month and type as fixed effects, and outlet as a random effect, showed that neither type of outlet or month significantly predicted their mean usage (p > 0.6).

## **Qualitative Results**

In this study, a qualitative analysis was conducted on five Querdenken outlets, namely Corona-Blog, Report24, Rubikon, Transition News, and Uncut-News. The study examined the extent to which the claims made by these outlets were original or copied from other sources, the types of sources used to support these claims, the number of clicks required to reach the original sources, and the extent to which the sources cited were congruent with the claims made.

The analysis found that Corona-Blog had the lowest percentage of claims that were translations or copies of other articles (18%), while Uncut-News had the highest percentage (86.54%). The other outlets had intermediate levels of copied content, ranging from 25.49% to 52%. This finding suggests that there is considerable variation in the originality of the claims made by these outlets.

The source types used to support the claims made by Querdenken outlets also varied. Authorities, papers or studies, and newspaper articles were the most common types of sources cited by Corona-Blog and Rubikon, while newspaper articles, blogs, and press releases were the most common types cited by Report24. Transition News predominantly cited newspaper articles, but other source types were also present in the dataset. Uncut-News mainly cited papers or studies and newspaper articles, with other source types also present.

The number of clicks required to reach the original sources also varied among the outlets. For most outlets, the median number of clicks required was 1, indicating that the sources were relatively easy to access. However, Uncut-News had a median of 2 clicks, indicating that the sources were less accessible.

In terms of source-citation congruence, the study found that the percentage of claims with no thematic link between the article and the source was generally low across all outlets. However, the percentage of claims with no logical link ranged from 8% (Transition News) to 36.96% (Corona-Blog). Moreover, 22.58% (Report24) to 71.43% (Uncut-News) of claims added additional information not found in their original source, and 20% (Transition News) to 71.43% (Uncut-News) of claims did not interpret the information correctly in the sense of the author of the source. These findings suggest that the outlets varied in the extent to which they accurately represented the sources cited.

Overall, the mean source-citation congruence (SCC) score ranged from 2.81 to 3.66, with a merged dataset having a mean SCC score of 3.39. The mean number of clicks was 1, the median number of clicks was 1.33 with a range from 1 to 7 clicks necessary. This indicates that while the outlets differed in the extent to which they accurately represented their sources, the overall level of source-citation congruence was moderate. Furthermore, given the rather low mean and median number of clicks needed, this shows that original sources were rather easily accessible.

## Discussion

The COVID-19 pandemic has had significant societal impacts, with citizens expressing their concerns through movements like the "Querdenken" movement in Germany. These movements often rely on alternative media sources to substantiate their claims and cater

to individuals who distrust mainstream organizations. However, the prevalence of disinformation in alternative media has become a growing concern, prompting research on its content, organizational dimensions, and effects on conspiracy thinking. Despite this, limited attention has been given to the language and rhetoric employed by the Querdenken movement. This study aims to fill this gap in the literature by conducting a comprehensive analysis of the linguistic features and strategies utilized by Querdenken media outlets to legitimize their views on the COVID-19 pandemic.

Existing research suggests that political sources play a prominent role in constructing pandemic news, indicating a strong reliance on mainstream media coverage of political elites (Mellado et al., 2021). However, it remains unclear how those who feel unrepresented by or disagree with the mainstream media or political establishment construct their own coverage of the pandemic. Preliminary research on the Querdenken movement indicates that seemingly scientific evidence is frequently employed by their media outlets to support their own lines of thinking (Marko, 2022). However, a thorough examination of the language and rhetoric used by the movement is lacking, and this study aims to address this gap by providing a detailed analysis of their language and sources of evidence.

The findings from the quantitative analysis in our study reveal important insights into the linguistic strategies employed by Querdenken media outlets. Querdenken media outlets exhibit a significantly lower emotional tone compared to newspapers, suggesting a focus on presenting objective information rather than appealing to readers' emotions. Tabloids, on the other hand, display a significantly more positive tone, potentially indicating a bias toward promoting a specific perspective or agenda. These results are comparable to previous studies such as Douglas (2021) indicating that a key driver behind pandemic news coverage is negative emotions. Querdenken media outlets also demonstrate a significantly higher mean health score than newspapers, suggesting a heightened emphasis on health-related issues and their implications. However, there were no significant differences observed between tabloids and newspapers in terms of health focus.

The analysis of research-related terms indicates that Querdenken media outlets employ these terms more frequently than newspapers, potentially indicating a stronger emphasis on scientific language and evidence-based claims. However, the framing of the pandemic changed over time, leading to a shift from a research and science-focused narrative to a more political one. This shift may have influenced the usage of research-related terms in media coverage, highlighting the dynamic nature of media discourse during crises. In a similar approach, Pan & Meng (2016) examined the role of media framing during different stages of a flu pandemic. Taking a crisis management perspective, the authors analyzed news coverage to understand how media frames influenced public perceptions and responses to the health crisis, emphasizing the importance of effective crisis communication strategies in managing public health emergencies.

The qualitative analysis provides additional insights into the types of sources used by Querdenken media outlets. The study finds that the percentage of original content varies widely across outlets, with some relying heavily on external sources while others generate the majority of their own content. Authorities and papers or studies are the most frequently cited sources in Querdenken media outlets, indicating an attempt to provide credibility and legitimacy to their claims. However, the source-citation congruence score reveals a generally poor alignment between claims and their sources, suggesting a lack of consistency and potential misrepresentation of information.

Overall, the findings suggest that Querdenken media outlets employ specific linguistic features and strategies to legitimize their views on the pandemic. These outlets appear to prioritize health-related issues and use scientific language to create an illusion of scientific legitimacy. However, misrepresentation of scientific findings, interpretation of information, and discrepancies between sources and claims were observed. This raises concerns about the manipulation and misinterpretation of scientific content to further their agenda.

The results of this study have significant implications for crisis communication and public health. They highlight the important role that alternative media outlets, particularly those affiliated with the Querdenken movement, play in shaping public opinion and discourse surrounding the COVID-19 pandemic. The study underscores the need to improve the communication of scientific information, ensuring its accurate interpretation and implications in the wider context. This includes the use of clear and accessi-

ble language, considering cultural context and social factors, and working with local communities and stakeholders.

To combat the spread of disinformation and conspiracy theories, policymakers should consider implementing measures to regulate alternative media outlets and promote media literacy education. These efforts are crucial in enabling individuals to distinguish between credible and non-credible sources of information, empowering them to make informed decisions about their health and well-being. Furthermore, as our qualitative analysis shows, a substantial amount of coverage in Querdenken media was translated and not original, underlining the need for international cooperation and guidelines.

It is important to acknowledge the limitations of this study. The findings are based on data from Germany, and caution should be exercised when generalizing the results to other countries with different political cultures and systems. The study focuses exclusively on the Querdenken movement and its affiliated alternative media outlets, and future research should explore other protest movements and compare their language use. Additionally, while the study identifies linguistic features and strategies, it does not directly test their perceived legitimacy or impact on public opinion. Further research is needed to investigate the psychological effects of these linguistic features and strategies on individuals' beliefs and behaviors.

In conclusion, this study provides valuable insights into the language and rhetoric employed by Querdenken media outlets. The findings highlight the urgent need for policymakers and health professionals to address the issue of disinformation and conspiracy theories in the context of the COVID-19 pandemic. By improving the communication of scientific information, implementing measures to regulate alternative media outlets, and investing in media literacy education, we can combat the spread of disinformation, increase public trust in evidence-based public health measures, and foster informed decision-making.

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## Self-reflection

Looking back on the past 18 months, we faced many challenges leading to valuable insights and lessons learned. Lessons that were important for the personal growth of each one of us but which might also help future teams from #class23, #class24, and so on.

But first things first: we, as team VINFO, are incredibly thankful for the help of our supervisors Dr. Kristina Schick and Dr. Eleni Georganta, as well as our tutors Paul Sieber and Junianna Zatsarnaja. They provided us with close guidance, especially Paul Sieber and Junianna Zatsarnaja, who visited nearly every Jour fixe and assisted us with their critical thinking. It was very important for us to hear the opinion of a third party, which is also capable of raising questions and pointing out areas where we still had work and brainstorming to do. This allowed us to stay on track and keep a level of consistency so that we managed to produce results that we are all very proud of. Also, we are very thankful to TUMJA, in particular Peter Finger and Dennis Lehmann, for funding our trip to Copenhagen for the 9th International Conference on Computational Social Science where we will have the opportunity to present our methods and findings.

Our individual expectations were similar, but it took us a lot of time at the beginning to figure out our project objectives. We researched all sorts of directions in the field of the "Querdenken" movement, so we had many different ideas and leads. For us, the identification of a topic was not a linear process but rather iterative. To give an example: we started working on the idea of analyzing the language of the "Querdenken" movement and structures on social media or messengers like Twitter and Telegram. We even coded the APIs to obtain the data. A few months in, we decided to stop pursuing this lead due to unsatisfactory results. Consequently, we then developed the idea of analyzing articles coming from various websites associated with the "Querdenken" movement – the idea we then stuck to until the end.

At the beginning, we were hoping for a linear process in establishing our topic. However, looking back at that phase of our project, the months that we worked on the first idea weren't wasted at all but were necessary – in fact, essential – for us to settle on a topic that truly interested us and was, at the same time, feasible. In addition to that, there were a lot of lessons we learned from reflecting on how we worked as a team. We learned how to communicate effectively, how we should assign tasks, what we should talk about in plenum, and when it is better to divide and conquer. So as a tip for all the following classes: Before thinking about a topic for too long, it might be helpful to start working on it first and iteratively come back to reassess your objectives. This phase helped us a lot in terms of teamwork even though we didn't stick to our initial focus. A further big learning outcome of our work together has been our collaborative team dynamics. We all have different study backgrounds, personalities, strengths, and weaknesses. As a result, we had different rhythms concerning our university schedules. Throughout the whole project, there were phases where some teammates couldn't commit as much time as others, and team members even lived in other time zones. Thus, we as a team needed to plan well ahead and at the same time stay flexible enough to ensure that everybody could manage to participate and engage. Thus, we changed the time and weekday of our Jour fixe several times, dividing tasks and giving enough freedom to the respective sub-teams to work out a schedule by themselves while maintaining the deadlines. We applied this concept throughout the whole period as it was easier to work as a smaller working group to achieve some milestones. For example, we assigned teams to work on data collection, development of tools, qualitative and quantitative analyses, writing texts, managing external relationships, etc. This felt very natural, too, as the tasks fell to the strengths of the team members who gained a certain level of expertise in the fields of their studies. So having all of those people coming from different backgrounds meant that we had to plan and communicate well to stay in rhythm but it also meant that everybody could focus on what they were good at and what they wanted to work on.

However, this self-reflection would be rather boring if we only pointed out the good things, right? So, what were the challenges throughout the project that we struggled with? A challenge was time commitment during intensive periods of studying, working, etc., and consequently also keeping up with deadlines. As we are a relatively large team, consisting of 7 team members, it was easy to stay in the background and let other people do the work. Especially during the early stages, when our weekly meetings had to be held via Zoom due to COVID-19, it was more difficult for us as a team to meet the deadlines due to a less engaging format. Connecting that with exam periods was the perfect mixture for forgetting project work. What helped us a lot with this problem were the seminar weekends as they served as intensive brainstorming sessions where we could all come together for two days and push our project back on track. Also, we organized a team weekend for working on our project and enjoying team activities.

Overall, we feel well-prepared for future scientific projects in interdisciplinary teams, as well as for further specializations during a Master's or Ph.D. program. We value the contacts we made, both scientific and friendly, and will stay in touch.

## ЛШ

6. TIME SCHEDULE

POSTER 1:

## VINFO – Virulent information

## How does misinformation spread?

#### **1. CORE PROBLEM**

Misinformation is a significant problem in today's society as the climate change and SARS-CoV-2 pandemic demonstrate. The latter gave rise to the group of Querdenker on which we focus to limit the scope of our research.



#### 2. RESEARCH QUESTION

How are COVID-related scientific information and events distributed and processed in the Querdenker community? To what extent is it still consistent with the original publication?

#### **3. PROJECT GOAL**

In our project we analyze the **out-of-context usage of scientific information**, leading to misinformation, in the **Querdenker community compared to the rest of society**. We aim to all ones for target groups ■ Create policy recommendations for target groups ■ Raise awareness of the emergence of misinformation

#### 4. METHODOLOGY





After the Kick-Off event and several brainstorming sessions where we combined the ideas from our different disciplinary backgrounds, we started with the literature research on Querdenken platforms and their language. We established our research questions, project goals, and project structure plan. At first, we performed API (Application Programming Interface) selection and testing to get access to data from Twitter and Telegram. Later we rejected this idea and just looked at Querdenken websites. At the beginning of 2022, we created a timeline with important dates during the pandemic, e.g. new variants, the first vaccine, and others. On the poster, you can see all the information about our project structure.

## ТШП

4. TIME SCHEDULE

Priddam aprintman

## **VINFO – Virulent information**

## How does misinformation spread?

#### 1. WHAT HAPPENED SO FAR?

- More concrete definition of our project goals:
- >> Analysis of positive and negative tone
- >> Analysis of scientific language
- >> Analysis of text similarity to primary literature/articles
- Formulation of these goals into a research plan, concretization of the research question
- Downloading of most of the necessary text data for the construction of the library and for testing
- Figuring out solutions for web scraping to semi-automatically fetch text from Querdenker websites
- Regular "jour fixe" meetings to increase team member engagement

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### POSTER 2:

In the summer, after getting a lot of feedback internally from TUMJA and, during the Symposium of class 21, for the first time externally from the public, we specified two research questions: To what extent is COVID-19-related information presented in a scientific manner in Querdenken online journalism? To what extent is this information aligned with information from scientific publications? We finished the download of several thousand articles from newspapers, tabloids, and blogs.

## ТЛП

## VINFO – Virulent information

Understanding the language of misinformation

#### 1. WHAT IS OUR PROJECT ALL ABOUT?

Misinformation is a widely recognized problem in today's society. We aim to better understand misinformation by analyzing a part of it which might be vital to its persuasiveness: Its language. For this, we aim to look at COVID-19related online journalism from publications belonging to the german "Ouerdenkor" movement, analyzing the scientificity and emotionality of their language using dictionary approaches. Furthermore, we want to look more closely at a subset of the articles to trace back their claims to their sources and evaluate how they process information.



#### 2. PROJECT PROGRESS AND NEXT STEPS



### POSTER 3:

Between the second and third posters, we achieved great progress. Especially during a weekend that we spent together in Füssen, we had lots of time to work on our project, develop new ideas, and strengthen the bonds in our group. For the methodology of our quantitative analysis, we constructed a dictionary that contains scientific terms to measure scientific tone. We familiarized ourselves with the methodology of the well-established LIWC-dictionary. For the qualitative analysis, we designed a code book to trace back randomized Querdenken articles and evaluate how they cite sources/evidence. We consulted "TUM|Stat" for the statistical analysis. On the poster, you can see the next steps beginning in January 2023. 

## TUTT

POSTER 4:

## ViNFO - Virulent information

Decoding the Discourse: Analyzing the Linguistic Features and Strategies behind the Querdenken Movement's COVID-19 Narrative

#### SUMMARY

#### IMPACT & SUSTAINABILITY

We investigated the language and rhetoric used by alternative media channels affiliated with the Querdenken movement in Germany during the COVID-19 pandemic. For quantitative analysis, we used a self-developed dictionary to examine emotionally, health-related language and usage of scientific terminology. For qualitative analysis, we analyzed the originality and congruence of sources cited.

#### **RESEARCH LIFE CYCLE**

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>> Our results fills the research gap in literature by providing a comprehensive analysis of the linguistic features utilized

- by Querdenken media outlets.
- International Conference on Computational Social Science in Copenhagen in July 2023. >> With our results we hope to contribute combating the
- > with our results we nope to contribute combating the spread of disinformation, increase public trust in evidence-based public health measures, and foster informed decision-making.

#### ACKNOWLEDGMENT

For the endless support and guidance, we're thankful to: Our great tutors Paul Sieber and Junianna Zatsarnaja, our supervisors Dr. Kristina Schick and Dr. Eleri Georganta and of course: Peter Finger, Dennis Lehmann and the entire office of TUMJA.



In the last part of our project, we tested the tone and word usage of Querdenken and tabloid articles with LIWC and our dictionary and performed the source-citation congruence analysis and statistical tests. We achieved amazing results that are shown on our poster. We were very focused on writing our research report, including the journalistic and scientific parts. Our journalistic part was reviewed by Thomas Fromm, a journalist from "Süddeutsche Zeitung" which was helpful and insightful. We submitted an abstract of our findings to the "9th International Conference on Computational Social Science" and we were very happy to be accepted and will give a presentation in Copenhagen in July 2023. 

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## **Highlights and Specials**

TUMJA offers its scholarship holders a wide range of opportunities for further activities. Some of these are developed and implemented by the office team, others by the scholarship holders themselves or together with partners of TUMJA.

Impulses from inside and outside enable scholarship holders and supporters to have a wide variety of experiences - in science and business, society and culture, as well as in sports and art. These encounters often give rise to new suggestions, which become new projects that are not directly related to the actual student research projects. At this point, TUMJA opens up to the entire network of TUM, partly also to the city society in Munich, and invites them to participate and to dialog.

Learn about the highlights of the past 20 months and the special projects we have been developing during this time on the following pages.

# VOVEMBER

## ECEMBER

## JANUARY

## FEBRUAR





In November 2021, the new scholarship holders came together as #class22 for the first time. At the Kick-Off weekend, which took place at TUM Main Campus as well as the Botanical Garden of Munich, they formed five research teams.



Taskforce Event again delighted the TUMJA members with the "Secret Santa" event. The unwrapping of the presents took place at the virtual "TUM-JA Christmas Party @ home".



Future Lab I for #class22 was held on January 29-30, part remote and part at TUM Main Campus. The teams learned about project management and worked on their research question. The scholarship holders also joined one of the taskforces.



The first round of the "Cross Challenge" as cooperation between TUM and the three art colleges in Munich (HFF, HMTM, and ADBK) entered its fourth month. The sixteen participants investigated "Caring Co-Existence" in three teams with three very different approaches.

## MARCH

## APRIL

## MAY



On March 17, the TUM-JA scholarship holders and alumni visited the Museum Brandhorst and took part in the guided tour "Andy Warhol – the dark side of pop". The museum visit was organized as part of the TUMJA Art Club.



With our pilot project "Wordshop", we invited TUM students, employees as well as alumni to develop a short story themselves and to be accompanied and advised by professionals. With the publishing house &Töchter and the experienced author Claudia Fabrizec, we were able to win great partners who supported us in the process.



On May 21-22, #class22 participated in their Intermediate Evaluation I in Dachau. They went into more depth about scientific work and project management.



At the end of May, the 11th "Master of the Olympic Lake" legendary dragon boat race took place in the Olympic Park. TUMJA took part with the team "OlympJA - Faster than Hermes" and won the third place in the category "costume".

# JUUE



In 2022, after a two-year pandemic break, the TUM Campus Run could finally take place again on site in Garching. We also offered a virtual run for all TUMlinge worldwide.



Another highlight was TUM Science Hack from June 24-26, 2022. Under the motto "Upgrade: Building a new reality" 57 participants displayed their creativity towards solving challenges provided by industrial partners and exceptional chairs of TUM.



On July 2, we said farewell to #class21 at their successful symposium "TUMorrow – Embracing the university of the future."



On July 4, Taskforce International organized a panel discussion about "Migration" with students from the New Mexico State University at the Amerikahaus Munich.



Subsequent to the Symposium, the scholarship holders of #class21 came together for their PAWE (ProjektAbschlussWochenEnde) at the Hans-Albers-Villa at Starnberger See and finished their project work.



TUMJA also hosted a EuroTe-QaThon weekend from June 10 to 12.

# SEPTEMBER

## OCTOBER

# **NOVEMBER**

## DECEMBER



From September 9-10, #class22 met for their Intermediate Evaluation II at the Evangelische Akademie Tutzing. Beside a poster presentation and discussion, the teams had a video production workshop.





In October 2022, the partnership with Pixida was successfully extended into seventh year and a new partnership with QuantCo was launched.



Beside the Kick-Off for #class23 under the motto "Less is More? Empowering individuals to focus on the essentials", #class22 completed their Intermediate Evaluation III in Wartaweil am Ammersee.



The Fireside-Chat on "Steps in my career & professional development – less is more?" jointly organized with TUM Graduate School took place on 22 November, 2022.



With our pilot project Wordshop, we produced the short story collection "Unerwartete Begegnungen". On December 15, TUMJA invited to a reading with the authors.

## JANUARY

## FEBRUARY

## MARCH

## APRIL



Facing the last months of their scholarship, the teams of #class22 trained their journalistic and scientific Writing skills at their second Future Lab Weekend at Schliersbergalm on January 20-22. The teams also worked together on planning their Symposium.



In February, the Flower Power Festival starts all over Munich. In keeping with the motto "Natur feiern in der Stadt", TUMJA is also offering a participatory program around the flower. One highlight is the second TUMJA writing workshop "Stilblüten".



The first Academy Talk 2023 was held on the topic of "New Technologies and the Perspective of Jewish Ethics". We were pleased to welcome Chief Rabbi Pinchas Goldschmidt and Prof. Dr. Astrid Séville as our talk guests.



The Akademie für politische Bildung Tutzing invited our scholarship holders to their annual conference – this time with the Bavarian Prime Minister Dr. Markus Söder.


On May 8, we invited to another Fireside Chat, jointly organized with the TUM Graduate School. The panel discussion on "Global Science, Global Career - or the importance of the proper international personal profile" was moderated by Samira Körner and Johann Ioannou-Nikolaides, both TUM-JA scholarship holders of #class23.





The ninth TUM Campus Run took place on May 10 in pouring rain but with a cheerful mood – in the tenth year of its existence. More than 2,000 runners started for the anniversary run.



On May 19-21, we focused on "Trustworthy Systems" at our yearly TUM Science Hackathon. And for the first time, we organized a Snackathon after the award ceremony as a get-together.



On June 9, 2023, the scholarship holders of #class22 presented their findings at the annual TUMJA symposium.

The PAWE (Projektabschlusswochenende) in the beginning of July 2023 will complete the scholarship period of #class22.

# Wordshop



With our pilot project "Wordshop," we invited TUM students, employees from science and administration, and alumni to develop a short story themselves in spring 2022, accompanied and advised by professionals. With the publishing house &Töchter and the experienced author Claudia Fabrizec, we had great partners at our side.

In December 2020, several book lovers from the environment of TUM: Junge Akademie met in the Book Club to read and discuss books together. It quickly became clear that they were not only united by a common desire to read, but also by the joy of writing their own texts. This gave rise to the desire to explore being an author and to discover the world of books and publishing houses. This shared passion for books finally gave rise to "Wordshop" at the end of 2021.

The writing workshop gave the participants a deep insight into the genesis of a book. Starting with the idea in each author's head, the course first focused on the own texts. In an editing workshop, the participants were then able to experience working with an edi-

tor. And the close cooperation with the publishing house &Töchter provided a unique insight into how the German publishing world works.

The resulting short stories were finally published in an anthology and presented at a public reading on December 15, 2022 at TUM.

The project was supported by the TUM Association of Alumni and Friends.





# Buddies4KNUST @ TUMJA

When interdisciplinary exchange among students and scholarship holders is simply not enough, international exchange comes into play. In April 2023, an exciting project was launched by the TUM: Junge Akademie. The Buddys4KNUST program pairs six Erasmus+ students from Ghana with seven current and former TUMJA scholarship holders or other TUM students who have previously been to Ghana. The project draws inspiration from the TUM.Africa Initiative as well as internal TUMJA projects such as the Buddies for Refugees program and the project group Africast from Class 2019. In the following sections, we will outline the motivation behind this project and its initial successes.

TUM aims to strengthen its collaboration with researchers from the sub-Saharan region of Africa. To achieve this, the TUM.Africa Talent program was launched in partnership with the Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi, Ghana. This program provides an opportunity for doctoral students from Africa to work alongside doctoral students from TUM's participating departments and research groups. Additionally, the program aims to foster the establishment of a long-term network. As part of this initiative, the TUM Maximilian Graf Montgelas program offers administrative staff the chance to enhance their international competence through overseas stays and exchange formats with renowned partner institutions. Through the utilization of TUM's extensive global network, participants have the opportunity to engage in direct dialogues with international colleagues, thereby gaining valuable insights into exemplary administrative practices. On April 20th, we had the pleasure of meeting Efua Arku, the Assistant of the President of the Kwame Nkrumah University of Science and Technology in Kumasi, Ghana. Our Managing Director, Peter Finger, along with scholarship holders, Erasmus+ students from Ghana, and buddies, discussed future projects with her. These projects, initiated by TUMJA and KNUST, are set to commence at the beginning of the winter semester 2023/2024. The aim is to develop a long-term cooperation between the two partner universities, with Peter Finger planning a trip to Ghana to meet Efua Arku. This collaboration may also lead to the formation of international teams as part of the TUMJA scholarship program. This not only enables interdisciplinary exchange but also fosters international cooperation, offering broader perspectives, particularly when considering the contexts of developing and developed countries.

The initial contact with the Erasmus+ students from Ghana was established through the TUM Global & Alumni office. Among the six students, there are four women and two men from various fields of study. They are studying at KNUST in different areas such as Life Sciences, Sport and Health Sciences, Management, Chemistry, Education, and Engineering. KNUST is the second largest university in the country and is named after Ghana's first president. The university is known for its high educational standards and extensive international network. During the interaction with the KNUST students, it quickly became evident that they are very curious, sociable, and ambitious, making them excellent candidates for exchange students at TUM. In early April, contact was established with the students to provide organizational support for their arrival in Germany. Peter Finger, Dennis Lehmann, and Monica Déchène arranged airport pick-ups and ensured that all students were accommodated in their student residences in Munich and Freising. In the days following their arrival, the students spent a lot of time with their buddies, addressing basic questions such as where to get a SIM card, where to shop affordably and conveniently, how the public transportation system in Munich works, what they need to consider when studying at TUM, and how to register their residence with the local authorities (KVR). Once these initial challenges were overcome, the intercultural exchange could begin. During joint excursions and lunches, there was a lively exchange and comparison of typical German and traditional African customs and traditions. The plan is to integrate the students into existing activities and events organized by TUMJA and invite them to participate in various events such as museum visits, hikes, and summer festivals for the duration of their stay.

We would like to express our gratitude for their commitment and participation in the program to the students from Ghana (Ama, Afia, Ben, Emmanuella, Eunice, Shadrack) and our buddies (Cedric, Fiona, Flo, Johanna, Katharina, Monica, Valentin), as well as to the organizing teams at the TUMJA office and TUM. Additionally, we would like to share some of the most memorable moments from the participants of the Buddys4KNUST program in a collage.

By Monica Déchène



# TUM Campus Run: Spectacular Run on the TUM Campus Garching

On May 10, 2023, the highly anticipated 9th TUM Campus Run took place at the Garching campus, hosted by the TUMJA office team and volunteers. Our annual event for the entire TUM community of students, staff, and alumni attracted over 2,000 enthusiastic runners of all ages and abilities, thus reflecting the inclusive nature of the event and the community spirit it fostered. With its super location and the record-breaking number of participants, the TUM Campus Run 2023 was an unforgettable experience for all involved, even though the weather gods did not mean well with us: in some spots, the campus run turned out to be a mud run.

On race day, the runners arrived in the early afternoon in Garching, and despite the rain, there was a palpable excitement in the air. The participants warmed up at the starting line, accompanied by the stu-

dent samba group "Praias da Isar." With its picturesque landscape and modern architecture, the TUM campus in Garching once again offered a perfect backdrop for the run. The route meandered through the sprawling campus with its iconic buildings, over the dirt roads of the community of Dietersheim, and along the river Isar, which kept the runners motivated throughout the race. The event featured different categories, including a 5.5km run and the 11km run, each for individual runners and teams. This year, we awarded two additional ratings: the most creative running clothes for individual runners and teams - under the motto "FlowerPower." As in previous years, Prof. Sonja Berensmeier and Prof. Filip Mees were the fastest professors to cross the finish line. The energy technology team was also able to repeat its great performance from previous years: Congratulations to team EES RAPID 1!





We are happy about the fantastic number of participants and are already looking forward to the 10th TUM Campus Run next year!



#### Highlights & Specials



To celebrate the anniversary of the Campus Run, we launched a "Flower Power" costume challenge and were thrilled by the creativity of our runners.

# TUM Science Hackathon rocked Garching again

In our yearly Science Hacks, students sprint-work on challenges by our partner companies and chairs/professorships over the course of a weekend-and they love it! The weekend is all about teamwork, applying your knowledge in praxis, and deep-diving into a topic. We had fantastic challenges from our partners and 85 registrations. This year we focused on "Trustworthy Systems," which encapsulates many of the developments currently underway or already implemented: be it space travel, communication pathways, or artificial intelligence. The advances of our time are often accompanied by little inadequate regulation, and we often lose track of the systems that have been developed. The goal was to develop systems that are safe and reliable for the consumer, putting quality and reliability first. Which our participants did day and night! So we provided them with plenty of food, drinks, and coffee to refuel.

For the first time ever, we organized a Snackathon after the award ceremony to get to know the other participants and supervisorsand with great success.

#### "The snackathon was really nice at the end! Meeting new and interesting people was my favorite thing in the overall event."

Check out more about us on our website or Instagram under @ja\_sciencehack where we got fantastic pictures from our team selfie challenge, work progress, and award ceremony.

Philipp Patzelt



# myt j-j:j: TITT

# #4allstudents of MUC



Bachelor | Master | State Exam | PhD





HM





#### What our participants say:

"I liked most the wide range of challenges from dashboards to algorithms, from spacecrafts to social media" "Perfect moderation"

"Our supervisor was amazing"

"The catering was amazing"

# TUMJA Symposium "Learning from Nature" of #class22

The bright sun is still high on the horizon over Munich when the curtains close shortly before 6 p.m. on June 9, 2023, at the Vorhoelzer Forum, the venue on the fifth floor at TUM main campus. The scholarship holders and more than 100 guests take their seats, chatting, after half an hour on the roof terrace dedicated to getting to know each other and having lively conversations. Calm returns.

Katharina and Rosa, members of the Taskforce Symposium, confidently guide through the program with a clear view of the proceedings. They have dedicated over six months to preparing for this event, together with all the other taskforce members and the external coaches Jörg and Markus. In addition to program flows, director plans, and speaker training, they developed marketing strategies and clarified event management questions such as "What do we eat and drink?" "Who is in charge of the technical team?" "Do we need an after-symposium party?" and many more. After the event, everyone – scholarship holders, alumni, management, friends, supporters, and guests – agreed that the taskforce members did everything right.

It was a perfect evening, and all five teams presented themselves in a way worthy of their nearly 20-month commitment and their work in the student research projects. The panel members, Dr. Andrea Geipel, Kati Nispel, and Gwillem Mosedale, discussed the topic of science communication and inspired the audience with their openness, clear messages, and wealth of experience.

The sun had already disappeared after the end of the official event, but the laughter and voices reverberated in the evening sky for a long time. The #class22 symposium "Learning from Nature" will be remembered by all participants.

Special thanks go to the scholarship holders, tutors, and supervisors for their creativity and perseverance in preparing the event. We thank our coaches, Markus Walsch and Jörg Puls, for their patience, empathy, and professionalism, and the members of the TUM student council, Oli and Tibor, for their reliable technical support. Thanks also to Rene and Kim from Crazy Bean for the delicious catering and to the entire TUMJA office team: Dennis, Constanze, Eya, Hasna, Onat, and Peter for their flexibility, motivation, and support. Finally, we thank Prof. Gerhard Müller, Director of TUMJA and representative of the university management, for enabling the Technical University of Munich to support the development and growth of TUMJA for almost 20 years.



#### Highlights & Specials



















**Cooperations** 154 TUM: Junge Akademie - Research Reports 2022

# **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.

#### HOCHSCHULE FÜR FERNSEHEN UND FILM MÜNCHEN

# 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.

#### Hochschule für <u>Musik</u> und <u>Theater</u> München

# 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.

# Industrial Partner – QuantCo

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

The team of over a hundred economists, 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.



# Cooperation with TUM: Junge Akademie

We started our partnership with TUM Junge Akademie in the academic year 2022/2023 thanks to several TUMJA alumni that joined QuantCo. Since then, we have organized two events and look forward to the ones still ahead!

Our first interaction was the workshop on "Data Analytics and Visualization" during the weekend at Schliersee in January 2023. Two colleagues joined on Sunday morning and provided a theoretical introduction to the art of data visualization in an academic and business context. Afterward, we brainstormed ideas on how to implement the new skills into the research reports of the teams.

As a follow-up to the workshop, we invited TUMJA scholarship holders to our new office in Munich for dinner and a tour. It was fantastic to see several TUM alumni mingle with the current cohorts and discuss the fields of data science, tech, and research.



# Industrial Partner – Pixida Group

The Pixida Group turns digital transformation into sustainable success by combining the strengths of its members from strategy consulting to professional services to end2end products and solutions. We create customer value by developing new business strategies, innovating product portfolios, and utilizing cutting-edge technology.

With experience from more than 500 successful projects and 400 experts, we are focused on customer success and eager to shape the digital future together.

The international business scope consists of eleven locations in Germany, the USA, Brazil, China and Portugal, a multinational team from more than 30 nationalities, and a well-established network of specialists and partners.

Pixida's continuous success is reflected by an average growth of more than 25% per year and multiple top-class awards.



# Cooperation TUM: Junge Akademie

Since 2016 PIXIDA GmbH is a cooperation partner of TUM: Junge Akademie. Our experts in digitalization, Internet of Things (IoT), and mobility exchange knowledge on promising solutions for urban and public challenges with passionate students.

The relationship has been strengthened since the start of our cooperation in several ways: PIXIDA offers inhouse workshops, supports project teams to develop ideas into applications, and has participated in all Science Hacks organized by TUM: Junge Akademie so far.

At the second edition of TUM Science Hack in December 2019 two student teams worked on the PIXIDA challenge on how to promote eco-friendly driving. Both teams developed Web-Apps to visualize the eco-friendliness of trips. The result was very impressive: both teams showcased live map visualizations, online sharing features, detailed trip details, and individual recommendations on how to improve eco-score.

From August 2020 to March 2021 several PIXIDA colleagues supported two TUM: Junge Akademie project teams in their ambition to develop mobile apps. Team TUMwelt developed an app to track individual urban mobility patterns with the goal to promote eco-friendly behavior among the young adult population. The focus of team AppCycle was on the re- and upcycling situation in the city. Shops & events, characterized by environmental awareness, as well as the locations of recycling stations were supposed to be centralized within this application. The PIXIDA colleagues offered mentoring in the fields of functional development, architecture, data security, and design.

The topic of the Science Hack in 2021 was "The New Normal – Sustainable & Inclusive Cities after the Pandemic". The two PIXIDA student teams developed web apps to visualize the occupancy levels of public transport and pointed out the potential of PI Labs IoT Gateway as a prospering business case. The provided data consisting of WiFi probe requests by mobile phones were used to estimate the occupancy levels within public transport vehicles. The final concept for a passenger counting feature was showcased within a dashboard application.

Last year, we have already participated in various events to evaluate further and new cooperation formats between TUM: Junge Akademie and Pixida. These included for example participating in the selection process of TUMJA scholarship applicants & mentoring one scholarship holder team during the initial kickoff workshop.

In 2022 PIXIDA hosted a coaching workshop in which a selection of class22 teams pitched their project plans and ideas to a group of experienced PIXIDA colleagues. With their different viewpoints and insights, they were able to challenge the students' pitches. As a result of the prosperous exchange the students could identify not only risks but also further potential in their concepts – and thereby elevate the excellent projects even further.

And within a few weeks of this writing, we will participate in the TUM Science Hack "Trustworthy Systems" in May 2023 with a challenge on how to build customer trust in a retrofit usage-based insurance solution by harnessing live crash detection functions to offer proactive, tailored customer support. We are looking forward to seeing the creative and innovative solutions the two teams will develop.

We would like to thank all the students for their high degree of social commitment and performance!

Let's continue our exciting and constructive cooperation in the future!



# CAP 162 Event 164 International 166 Marketing 168 Mentoring 170 Recruiting 174 Symposium 176

# **Taskforce CAP**

As the Taskforce CAP, we manage the cooperation between TUM-JA and TUM-external parties and we organize the TUM Science Hackathon.

The TUM Science Hackathon is the largest event we organize. During this event, industry partners and university chairs propose exciting challenges, which combine issues from different scientific disciplines. Teams of up to five students work out solutions to these challenges, supported by professionals from the worlds of business and science. At the end of the TUM Science Hackathon, the best three projects are rewarded with great prizes.

Taskforce CAP of class 22 organized the fifth edition of the TUM Science Hackathon. It took place in June 2022 under the motto: "Upgrade: Building A New Reality!" and was the first Hackathon that took place in person since the beginning of the Covid pandemic. The Hackathon turned out wonderfully, with 57 participants, 6 partners and 3 jury members. In the month leading up to the event, we had the opportunity to learn a lot: from partner communication

and marketing to the organization of catering. We CAP members enjoyed the process very much and had the chance to meet many passionate students from different fields of studies.

Being part of Taskforce CAP was an experience rich in learning and exchange, and an amazing addition to the TUMJA experience.

Class 2022 Ioan-Daniel Craciun Pia Gutsmiedl Emilia Litzka Matthias Pixner Lenz Pracher

Taskforce Senior Philipp Patzelt

#### Class 2023 Vedant Gupta Sarah Lockfisch Peter Ridilla Magalie Roß Yuan Yuan Milina To

#### Taskforces

OSP

RE STOR





# **Taskforce Event**

#### Introduction

We are Taskforce Event of the TUM: Junge Akademie, an independent working group that focuses on bringing together active scholarship holders, tutors, alumni, and supervisors. Our first and foremost goal is to connect all members of TUMJA and strengthen our community with people from different disciplines and cultural backgrounds. We achieve this by organizing a variety of events throughout the year. These events range from museum visits to rooftop basketball games, from our TUMJA Christmas Party to a city trip to Augsburg.

#### **Getting Active**

The most prominent, TUM-wide event organized by TUMJA and Taskforce Event is the TUM Campus Run. As always, professors, employees, and students competed in the 5.5 or 11 km distance on tracks around Campus Garching. Furthermore, participants came together in teams of five or more, and many chairs and student groups participated. It was great to see so many members of TUM out there on a great summer day. The event was nicely rounded off by the GARNIX festival that took place simultaneously.



After the Campuslauf, we continued our summer events in a sportive way: First, the dragon boat race "Master of the Olympic Lake" took place, where we joined as a team "OlympJA – Faster

than Hermes." This competition between TUM and LMU students took place on a beautiful summer day in the Olympiapark with an awesome atmosphere. We took home the third prize in the category "Creative Costume" and will be back in 2023. In August, we came together for a game of basketball over the skylines of Munich at the Bellevue di Monaco rooftop court.

#### **Representing TUMJA**

At the start of each semester, we organize the MIA, the Münchener Initiativen Abend. Here, student organizations present themselves to potential new members, recruit and network with each other. In April of 2022, the MIA took place for the final time and will be continued as TUM Student Club Fair. We also represented TUMJA at various events such as the IKOM.

#### Strengthening the TUMJA Community

After a break of two years, the TUMJA Sommerfest returned in 2022. We met at the beach volleyball courts in Garching for a barbeque with many TUM-JA members. There was a great exchange between alumni and the current generation of scholarship



holders; we chatted and enjoyed the food and company.

With the success of the Sommerfest on our backs, we further planned and hosted the Christmas party in the TUMJA office. Many of our members showed up in their festive Christmas sweaters and hats and together with the great decorations in the office, the Christmas mood was established quickly. Then, groups of scholarship holders from class 22 and class 23 took part in a Christmas-themed pub quiz and a gingerbread house-building competition. With their incredible pub quiz performance and a gingerbread TUMJA office, Team "Wunderschöne Gewinner" took home the first place. We invite you to join us again for the Sommerfest on 14.07.2023 and the Christmas Party on 09.12.2023.

#### **Traveling Bavaria**

This year, our events were not limited to Munich itself. Over the semester break, alumna Magdalena invited us to Freising to show us the city, the TUM Campus, and most importantly "Hörsaal 13," a famous pub in Weihenstephan. Our next city tour was a day trip to Augsburg. A group of scholarship holders took an early train from Munich and after a nice breakfast, we toured the city with a local guide. We gained insight into the rich history of Augsburg and visited famous buildings such as the town hall with the opulent "Goldener Saal." After that, we relived some childhood memories at the Augsburger Puppenkiste, where we watched a performance of the Wizard of Oz. We finished the day in Augsburg with a stroll over the Christmas Market and returned to Munich.





#### **Visiting Cultural Sites**

During the summer semester, we also visited several exhibitions in the museums of Munich. We started by visiting the Museum for Urban and Contemporary Art (MUCA), then continued with a guided tour through the Pinakothek der Moderne, visited the exhibition on Polish Symbolism called "Stille Rebellen" in the Kunsthalle



München, and finished our event series with the Lange Nacht der Münchener Museen (Munich's Long Night of the Museums). During this night, we networked with other scholarship holders and visited several different museums on the same night. We saw everything – from an exhibition on Munich's party culture during the seventies to the "Blaue Reiter" exhibition at the Lenbachhaus to the Kunstlabor 2, a walk-in art installation. We completed our cultural program by a series of visits to the Münchener Kammerspiele.

#### Outlook

We had a great time with you in the past year. The Taskforce Event is always organizing new and exciting events throughout the year and we hope to see you again soon!

#### **Class 2022**

Sophia Duggen Miguel Marcano Bethencourt Alexander Sobieska Steffen Wedig

Taskforce Senior Magdalena Bader

#### **Class 2023**

Florian Brandl Johann Ioannou-Nikolaides Sandra Gross Alexandra Cara Marquardt Franka Exner Carolin Niedermaier

# **Taskforce International**

Over the past one and a half years, Taskforce International has made a highly anticipated comeback, beginning with class 22 and continuing with class 23. Despite facing the challenges posed by the pandemic, a fresh team has taken the reins, carrying forward the ongoing initiatives while embarking on new endeavors. The team's core objective remains unaltered: fostering connections between the international community and the TUM: Junge Akademie. But do not let the term 'International' mislead you! We like to think that the Taskforce International's scope extends beyond the global landscape as it is dedicated to spreading awareness about TUMJA and promoting the scholarship program both internationally and locally.

The Taskforce International team has worked on many projects throughout the past year through their dedication and the help of its collaborators. One notable example was the successful organization of the TUM contribution to the prestigious MIT Career Fair. The first event was conducted online, providing TUMJA scholarship holders with a valuable opportunity to connect with renowned companies and explore potential career paths. The second event, held in person, fostered a dynamic and engaging environment for both students and participating organizations, facilitating meaningful interactions. Sadly, there were no funds to send scholarship holders to Boston. However, a scholarship holder already in place attended the event and was briefed by the Taskforce International. Hopefully this has set the tone for future years, and we hope to have more members attending the event next year!

In collaboration with its counterparts from New Mexico State University, the Taskforce International team orchestrated a special event at the Amerikahaus Munich on July 4th. Dr. Sabine Hirschauer from the department of government (NM State, USA) and a group of students visited our team during the first week of July. This event served as a platform to promote cultural exchange and celebrate the friendship between the two universities. It featured intellectual discussions, presentations, and networking opportunities, creating a truly enriching experience for all participants. The discussions revolved around "Migration and Health."

The team actively participated as a guest in the IKOM career fair hosted at TUM, showcasing the TUMJA scholarship program to a wide audience. The presence of scholarship holders at the IKOM played a pivotal role in establishing connections between students and potential employers. The team's efforts in organizing the TUM-JA booth garnered attention and generated significant interest among talented students. Some of them are now part of Class 23!

Moreover, Taskforce International made substantial contributions to the exchange program between TUMJA and the Kwame Nkrumah University of Science and Technology (KNUST). Its unwavering commitment allowed for the establishment and nurturing of this partnership, enabling students from both institutions to engage in a rewarding cross-cultural academic experience. By facilitating the exchange program, Taskforce International actively promoted international collaboration and broadened the horizons of TUMJA scholarship holders.

Many projects remain in the books and Taskforce International is currently working on implementing the "Break the Bubble" program. An initiative that will try to build a bridge between the current scholarship holders, TUM, and the oncoming Erasmus students who attend our university each semester.

However, the greatest challenge remains local and not global! Everyone at TUM should know about TUMJA, and that is now part of the Taskforce International's duties. At the dawn of a new era, the Taskforce is more than ever part of TUMJA. Its greatest ambition? Think global, act local.

#### Class 2022

Mohamed Zied Jaber Sophia Maria Rebecca Leiß Valentin Pauli Constantin von Witzleben Julius Johannes Wenzler Class 2023 Samira Körner Sagnik Banik Moritz Friedemann Raluca-Ana-Maria Barna Claudia Guadarrama Serrano



# **Taskforce Marketing**

We, Taskforce Marketing, aim to make the TUM: Junge Akademie more visible to students and employees at TUM, as well as to potential partners and employers outside of TUM. This requires us to be in close contact with the main office and other Taskforces to coordinate our activities. From building social media contents to creating concepts for branded TUMJA merchandise, Taskforce Marketing is responsible for raising the public profile of TUMJA through strategic campaigns.

Taskforce Marketing is not only responsible for the TUMJA merchandise catalog, but also designs smaller branded items like postcards and flyers that help to continuously raise awareness of TUMJA. In general, our work expands the borders of our own Taskforce. For example, we collaborate with Taskforce Event in order to help them promote their events, work together with Taskforce Symposium to promote the TUMJA Symposium and represent TUMJA on yearly events like the IKOM. Finally, we are also responsible for conducting interviews with TUMJA alumni.

Our members come from various fields of study – often without a background in marketing. However, this does not impact our performance: together as a team, we come up with creative ideas for promoting TUMJA. Creating new and exciting solutions is essential to our task. For our taskforce, it is not necessary to be an expert with professional design tools, but simply to exhibit a general creativity and an interest in helping TUMJA grow its reach at TUM and beyond.

Our Taskforce has a lot of freedom when it comes to conceptualizing and implementing projects. Also, new members have the opportunity to lead their own projects and to experiment in the field of marketing. We aim to offer hands-on experience to each of our members, no matter if they want to learn new skills or apply their existing skills with us. The wide range of our work gives everybody an opportunity to find a task that best suits their abilities. Students aspiring to join Taskforce Marketing will thrive by facing these challenges with enthusiasm and creativity.

Class 2022 Christina Schwalm Julius Miers Manfred Klemt Seong-Min Jun

**Taskforce Seniors** David Noachtar Elena Tangocci Class 2023 Camila Loaiza Santos Lena Maria Straßer Tina Schiele Shaoming Zhang



# **Taskforce Mentoring**

The Taskforce Mentoring is responsible for the mentoring program of current scholars of the TUM: Junge Akademie. We strongly believe that mentoring offers great benefits for both sides and is a valuable part of the curriculum of TUMJA. Our program offers the opportunity to establish personal contact between scholarship holders and alumni of TUMJA. For Class 22, it was the first time that 3 TUM Emeriti of Excellence also participated as mentors. In this way, individual advice and suggestions from experienced alumni and professors can be passed on to the younger mentees. At the same time, the mentors have the opportunity to keep contact with their alma mater and to benefit from the knowledge and enthusiasm of the next generation.

The eleven matched tandems of Class 22 started their mentoring program in June 2022. The Kick-Off Event of Class 22 and the Closing Event of Class 21, where the mentors and mentees of the past class reflected on their successful mentorships and the current class was able to meet their new mentors, were hosted in the Vorhoelzer Forum. After an exciting opening speech by Peter Finger and an interesting introduction to the mentoring program by Annabel Matz, all participants mixed in a relaxed atmosphere with good food, stimulating conversations and wonderful summer temperatures with a great view over Munich until late into the evening. First experiences were exchanged, burning questions were answered and new people were met, which is, after all, the goal of the mentoring program.

After the mentoring kick-off, the tandems can usually shape their interaction very individually: Although mentor and mentee should meet at least four times over the course of a year, the frequency as

well as the location and topics discussed are determined individually. Both academic issues and personal topics can be discussed.

After one year, it is up to the mentor-mentee tandems to decide whether they wish to continue the mentoring tandem by themselves. At the TUMJA Symposium in June 2023 at the TUM Audimax, the mentor-mentee tandems of Class 22 will have their Closing Event and the mentor-mentee tandems of Class 23 will have their Kick-Off Event. A great opportunity to get to know each other and celebrate in an inspiring atmosphere!

Our mentoring program was inaugurated in 2019. We would be delighted if the positive trend that has prevailed since 2019 continues and many alumni and emeriti of excellence as well as new scholars agree to participate in our mentoring program. Together with our three new motivated members from Class 23, we are preparing the mentoring program for this year.

We look forward to taking the next steps. Stay tuned!

Your Taskforce Mentoring

**Class 2022** Nina Dieminger Til Hagendorn Wenxuan Li Kathrin Schmalzl

Taskforce Senior Robin Weiss Class 2023 Sophie Ebert Veronika Hofmann Helene Jung Xufan Lu



# **Taskforce Recruiting**

We, the Taskforce Recruiting, are responsible for selecting the most motivated students for a new scholarship year.

To be able to recruit new scholarship holders for the TUM: Junge Akademie (TUM: JA) 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, which are then nominated by us and Prof. Müller for the TUM: JA.

Another part of the application process involves the planning and conduction of three information events for interested students. Here, we give the students the opportunity to meet active members and gain firsthand insights into the TUM: JA. Due to the pandemic, we were limited to online information events last year. Thus, we are glad to announce that we can organize in person events again this year.

Afterwards we proceed with the application phase during which we evaluate the incoming applications of potential scholarship holders based on predefined criteria. Here, the applicants' personal motivation and ideas regarding the call are most important. Of course, we always aim to guarantee an objective and unbiased evaluation of the applicants, why we ask for anonymization of letter of motivation, CV and essay/video. This ensures that we can rule out unconscious influences on our decision-making. Since feedback on this improvement was positive, we decided to continue with it.

Last but not least, we are responsible for organizing the selection days. During these two days, the applicants are asked to participate at various individual or group tasks. For instance, presenting their proposed project ideas described in the essays, as well as having an interview with other scholarship holders, tutors, or supervisors. Last year we changed the place of the evaluation into the Wiki. Furthermore, we established a new scoring system, as academic marks (1.0; 1.3, etc.) seem no longer appropriate. We will use this new scoring system for this application process as well. This new score should facilitate the comparison of the applicants and helps assuring that the selection process is fair and replicable. Accordingly, based on performance, about 40 to 50 students are chosen to participate at TUM: Junge Akademie.

Of course, we don't lay low during the winter. We are often in contact with the other Taskforces Event, Marketing, or CAP and try to support them in their objectives the best we can.

The greatness of a community is most accurately measured by the compassionate actions of its members. We are proud to be able to contribute with our work to actively shaping the unique and excellent atmosphere of the TUM: Junge Akademie in the future.

Class 2022 Laura Gentner Tobias Loferer Lucas Schnack Benjamin Villard Corinna Winkler

**Taskforce Seniors** Andrea Schittenhelm Wolf Thieme Class 2023 Daniel Gögelein Johanna Lebmeier Vivian Meier David Schuster Ines Velasco-Martinez Letizia Wörrlein



#### Roadmap

As every year, we are looking ahead at four major milestones. At this point, the new students have already been nominated and are registering for the information events. Throughout summer, we will accompany them all the way to their final acceptance in the Junge Akademie.



#### Anonymity

One special feature during the application process: we ask our applicants to provide their applications in an anonymized form. This means that no names or pictures should be provided. Even for the videos, we ask applicants to avoid filming or recording themselves, to make the process more objective and fair.

4000 Nomimations from 40896 Total Students



#### **Nomination Percent**

In past years, we decided to give small departments a slight advantage in the name of interdisciplinarity.

This year we decided to automate the generation of the percentages to make them more systematic. We nominate 10% on average, 7% as a minimum and 25% as a maximum.

# **Taskforce Symposium**

Symposium (ancient Greek *sympósion*) originally stood for a banquet, but today it refers to a scientific conference, providing a channel for the exchange of information between researchers. Here at TUMJA, we too get a chance to present our research projects at the end of the scholarship program. The TUMJA Symposium is not only a platform to present the results of the research projects but is also aimed at being a fun and entertaining evening for all attendees.

Taskforce Symposium has one giant task – to organize this yearly symposium, which generally takes place at the end of the 20-month long scholarship program. To make the symposium not only conceptually interesting but also special for the graduating cohort, our taskforce has full creative freedom. Ideally, the ideas for the event are gathered a year beforehand. Over time, each detail is ironed out and every minute is carefully planned. This feat requires a very good understanding and close cooperation between the members of the taskforce and the project teams of the class. Each team member plays a vital role in this grand planning and is wholeheartedly supported by the TUMJA office. We are also guided throughout the process by Mr. Markus Walsch, who is a professional event management coach, and Mr. Jörg Puls, a professional moderation trainer.

The planning of the symposium generally starts after the end of the previous symposium. The taskforce members of the current class, in our case class 22, gather the initial ideas and come up with a rough plan, starting with the basics. We are later joined by new members from the next class (class 23) and our team is further strengthened. The newer members learn through the process to organize their own symposium in the coming year. We are constantly guided and advised by our taskforce senior Paul Sieber. Planning of the symposium exposes the members of the taskforce to the real world, where communication is the key. Contacting external parties such as keynote speakers, financial partners, technicians, caterers, and many more is pragmatic training for us. Apart from external contacts, we also must be in constant touch with other taskforces such as Taskforce Marketing, which helps us achieve a wider audience for our event, and Taskforce Event, which takes care of the after-party.

Planning the symposium is an iterative process, repeating and improving with every year. In planning this year's symposium, we learnt from the previous years' experiences. This planning brought us closer and made the process a memorable and fun experience for all of us.

Planning the symposium is most fun when it is done together as a team. Luckily, the interests of our interdisciplinary team range widely: some members love to do designs of posters and invitation cards while others prefer organizing or moderating weekly meetings. Currently, we're working on the final details for a successful symposium. From planning the dry-run to organizing the decorations, everything has to be fully prepared and fine-tuned by the day of the symposium. At our last weekend with the teams we started working on the all-important team presentations which are the culmination of the program and the centerpiece of our symposium.

We are all really looking forward to welcoming you at the event!

Your Taskforce Symposium.

Class 2022 Katharina Küllmer Aastha Chandiwala Vinh Phuc Tran Rosa J. Weidenspointner

#### Class 2023 Rui Yee Loke

Luisa Metten Euridice Pinheiro Vieira Harke Flavio Principato Ziwei Wang

Taskforce Senior Paul Sieber

# TIM SYM LEARNING POS FROM IUM NATURE

FRIDAY JUNE 9, 2023

18:00 - 20:00

# VORHOELZER FORUM RCISSTRASSE 21, 80333 MUNICH Image: Construction of the state of the st


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Initiated from the idea of creating low-threshold sex education for everybody, our group is working towards determining a sex education system, which will not remain solely as information written in a textbook, but which can truly reach out to students and be implemented in their everyday life.

ERIK\*A is the abbreviation of the German title ERneuerungs-Initiative für Kompetente Aufklärung. Our current step is to determine a target for competent and inclusive sex education and to compare it with the current state of sex education in Bavarian schools. With the motto "Aufklärung macht Schule," the final product of the research will be a handout that can be provided to the ministry or schools to redesign sex education based on the results of the mixed-methods study.

#### **Hypothesis**

We assume that there is a gap between the current sex education that is executed in Bavarian schools and a holistic sex education that is demanded by experts and students. To investigate this potential gap, we pose the following hypotheses:

- 1. Inadequate curriculum
  - We expect the Bavarian curriculum for sex education to be inadequate when compared to the demands of experts, empirical research, and students
- 2. Inadequate execution
  - We expect that the execution of the curriculum's content is inadequately executed due to a lack of (financial, personal, ...) resources
- 3. Hurdles to adequate sex education
  - We expect that the execution of a more holistic approach to sex education is hindered by poor execution on the part of the teachers and/or school
  - We further expect that the execution of a more holistic approach to sex education is hindered by a lack of seriousness and motivation on the part of the students
  - Finally, we expect that the execution of a more holistic approach to sex education is hindered by disagreement and protest on the part of the students' parents

Further, through interviews with experts, we will develop an experimental approach for holistic sex education.

#### Methods

The project will be carried out in the mixed-methods study approach, which can be divided into four important milestones:

- 1. Analysis of the Bavarian curriculum for sex education in schools to determine the current nature of this education.
- Conducting interviews with experts in order to classify the current position from a professional perspective and to collect ideas for a potential target state. Interviews will be conducted with teachers, psychologists, doctors, therapists, associations, organizations, youth workers, service providers, etc.
- Literature analysis for topics of sex education: filtering of potential problems with sex education and approaches for sex education reform.
- 4. Conduct a survey on topics related to sex education based on the results of the expert interviews. The aim of the survey is to map the state of knowledge and to evaluate requirements for sex education identified in the interviews. The study is aimed at people of all ages, ethnic backgrounds, and genders, but most specifically to school pupils.

#### Team

Tina Schiele Johanna Lebmeier Rui Yee Loke Sophie Ebert Daniel Gögelein

#### Tutors

Monica Déchène Nico Michel

#### Supervisor Prof. Dr. Doris Holzberger

Dr. med. Katharina Tropschuh

# **Healthy Habits**

## **BeHealthy**

Small steps, giant gains

#### OOAL.

Enhance overall litestyle and promote healthy habits among young adults by utilizing interactive instructions on social media to break down habits into small tasks.

#### RESEARCH QUESTION

Can social media be an effective tool to build healthy habits through the integration of interactive multimedia content for task completion and content sharing among users?

#### FIND OUT MORE

- Small actions can be easily incorporated in our daily routine and become a habit.
- Targeting young adults interested in building healthy habits through social engagement with their friends.
- · The app uses interactive multimedia, such as pictures to
- engage social media users.

  Users can complete tasks and view content shared by their



PROJECT STRUCTURE PLAN

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Social media is a powerful environment, which creates trends that spread virally and reach a large audience around the world. This effect is difficult to control. Nevertheless, our team asks the question: Can we use the experience of sharing photos with friends on social media to promote the building of healthy habits?

Many people want to improve their lifestyle, but getting started on such a big task can seem overwhelmingly difficult and discouraging. However, it has been shown that breaking down big tasks into small ones can help with incorporating new habits into our daily routine. Building on that, our project seeks to help people develop healthy habits over time by regularly challenging them with simple and fun tasks promoting physical, mental and environmental health.

As our delivery method, we chose a social media platform where users can share pictures of themselves accomplishing their challenges.

Our target population consists of young adults interested in developing healthy habits through social engagement with their friends.

To evaluate the success of our project, we will analyze app usage data and surveys filled out by app users.

#### **SMART** goal

Focusing primarily, but not exclusively, on our peers, our goal is to have 100 people state in a questionnaire that our social media app helped them build a healthy habit, confirmed by their app usage, by December 31, 2023.

#### **Research question**

Can a social medium be an effective tool to build healthy habits by breaking them down into small tasks and sharing their completion with other users?



#### Team

Raluca-Ana-Maria Barna Moritz Friedemann Sandra Gross Helene Jung

#### Alexandra Cara Marquardt Flavio Principato Magalie Ross Camilla Loaiza Santos

### Tutors

Jan Kochanowski Leonard Schmitt

### Supervisor

Prof. Dr. Florian Röhrbein Prof. Dr. Volker Nürnberg

# Somnoactive



Poor sleep is a major problem in today's fast-paced modern society, reducing productivity, affecting social relationships and causing numerous health problems. The aim of Somnoactive is to create an effective routine that promotes regular and improved sleep and therefore overall wellbeing.

Our hypothesis is that by following a short, low-threshold daily exercise routine that includes strength, stretching and mindfulness exercises, along with scientifically proven measures to enhance the circadian rhythm,<sup>1</sup> we can have a positive impact on people's sleep. Among other things, we hope to reduce the time it takes the participants to fall asleep, reduce the number of times they wake up during the night, increase the feeling of restfulness in the morning and reduce the feeling of tiredness during the day.

To measure the effectiveness of the routine, we will use both questionnaires and activity trackers. All participants will be asked to complete questionnaires on a regular basis to track their sleep quality, sleep duration and any changes they experience during the study. In addition, a subset of participants will be fitted with activity trackers to measure their physical activity levels and sleep patterns.

The participants will follow our daily morning exercise routine and will be given suggestions for improved sleep hygiene, from which they are free to choose which they integrate into their everyday life. We will collect data during a period of 30 days and also on two separate occasions two weeks before and after the routine to compare results and measure the effectiveness of our intervention.

1 Cycles in the human body that help to anchor the human internal clock.

At different stages of the trial, we will also conduct interviews with participants to collect qualitative data about their experiences. We will ask questions about what participants already know about good sleep hygiene, what they found new or surprising, which interventions were easiest to incorporate into their daily lives, and which they plan to continue.

In summary, our student research project aims to create an easy-to-implement daily routine that promotes effective sleep and improves its quality. By combining a daily exercise routine with scientifically proven measures to enhance sleep quality, we hope to see an improvement in participants' sleep quality. Our use of questionnaires, activity trackers and interviews will allow us to collect both quantitative and qualitative data to measure the effectiveness of our routine and gain insight into participants' experiences.

#### **Team** Florian Brandl Vedant Gupta Johann Ioannou-Nikolaides Samira Körner

#### Tutors

Genoveva Müller Elisa Rodepeter

#### **Supervisor**

Vivian Meier

Luisa Metten

Lena Straßer

Sarah Lockfisch

David Schuster

Prof. Dr. Philipp Reiß Prof. Dr. Manuel Spitschan



Projects in Prospect

# **Tick Talkers**





Franka Exner Mathematics

Claudia Guadarrama Serrano Chemical Biotechnology

Xufan Lu Information Systems



Carolin Niedermaier Medicine



Yuan Yuan Milina To Management and Technology



Shaoming Zhang Physics / Computational Science and Engineering

Tick Talkers	Climate Change o	n Lyme Disease	Proliferation	TUT
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Research Goal: We are studying the relation between different climatic factors and human activities and the incidence of Lyme disease cases in Bavaria, Germany. With the current scenario of climate change, the aim is to create a predictive model, which uses as input different climatic scenarios that can serve to potentially improve the response of pharmacies, medical services and the general public by analyzing the available data and concentrating on the endemic region.

Research Question: To what extent do climate change induced factors and human related activities impact the prevalence of Lyme disease in Bavaria, Germany?

Hypothesis: Changes in seasonal climatic factors significantly increase the incidence of Lyme disease cases in Bavaria.

Toy Models Implementation: Currently we've developed and implemented two preliminary models that accurately reproduce the historical progression of Lyme disease in Bavaria and Germany, demonstrating promising accuracy. These models will be refined with the addition of more factors and data.

Methods: We are divided into 2 subgroups: Team Research and Team Modeling.

- Team Research focuses on identifying the core issue, by understanding Lyme disease's life cycle, the disease pathology and incidence and case studies on other disease incidence affected by changing climatic conditions.
- Team Modeling engages in hypothesis verification and model exploration. Rigorous testing and analysis validate the theoretical framework, while exploring various models and algorithms enhances understanding and prediction capabilities.





#### Team

Carolin Niedermaier Claudia Guardamarra Serrano Franka Exner Letizia Wörrlein Shaoming Zhang Xufan Lu Yuan Yuan Milina To

## Tutors

Leonardo Giannotti Daniel Khadra

### Supervisor

Prof. Niklas Fanelsa Prof. Dr. Enkelejda Kasneci





# **TUManywords**



#### Who We Are

We are Team TUManywords. Our group comprises 6 members from different academic backgrounds and we cover everything from Biochemistry, Mathematics and Computer Science to Aerospace.

#### What We Do & Why We Do It

Our central research area is that of linguistic and structural simplification.

Let us explain the problem. The use of language and the manner in which information is displayed around us is often unnecessarily complicated. Take a look at the TUM website – many of its subpages are hard to use because of confusing structure, the large number of links one needs to follow to get the desired information, and because of overcomplicated language. This is especially noticeable on sites informing prospective students about the application processes for the various study programs.

This is why we want to simplify the websites information pages in such a way as to enable students to find all relevant information with a specified number of clicks and so that the number of help requests that the administrative offices receive reduces significantly.

#### **How We Envision Our Project**

The goal is a website that clearly and concisely informs people about the application process. To reach it, we will follow the steps illustrated in the accompanying chart. In summary, there will be two rounds of usability testing. The first round will be performed on the TUM subpage we choose, without any changes. In the second round, we will present an improved version of that webpage to see if our simplification measures have the desired effect. If so, we will discuss the possibility of modifying the TUM website (i.e. the specific subpage) in accordance with the results from the tests we have conducted. Additionally, we will set up structural and linguistic guidelines for improved website design for sites presenting information about applications.

#### **Concrete Goals**

In more precise terms, we aim at the following outcome: We want...

- ... the percentage of students asking for help (i.e. emails or phone calls reaching the admin offices) to drop by 25% at least.
- ... non-native German speakers not to use the option to translate texts more than five times on average and less than during the old application process.
- ... applicants with reading disabilities not to ask for help more than five times on average and less than during the old application process.
- ... average screen time and number of clicks to drop by 50% at least.



#### 1st round of usability tests

Participants obtain tasks to fulfill on the current TUM website, e.g., "You want to apply to study program XY at TUM. Use the website to find out which steps you need to take, which documents you need, and which deadlines you have to meet."

During these tests, we collect data concerning:

- Performance measure
- Direct observation
- Subjective user preference



Using the testing procedure described above, we would like to answer the question of whether our combination of proven and novel methods for the simplification of TUM's websites informing users about the application process for study program XY can reach significantly better usability scores than the original sites to guarantee a more accessible user experience.

Keep an eye out for the development of our project and the results!

#### Team

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#### **Tutors**

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# Become a Part of the TUM: Junge Akademie

#### **Business Partner**

The TUM: Junge Akademie cooperates with companies from economy and science. You, as a company, can benefit from the cooperation with the TUM: Junge Akademie and its excellent and highly motivated scholarship holders, who might even become part of your company one day. Are you interested? Then please contact our management or the Taskforce CAP (Contacts, Alliances, Partnerships).

Our partners have the opportunity

- to participate in selected events as well as the annual TUMJA Symposia
- to invite the scholarship holders to their company or institutions
- to assume mentoring for individual students or as part of projects
- to participate actively in expert discussions

Private individuals have the opportunity through a support partnership

- to participate in selected events as well as the annual conference
- to acquire personal sponsorships
- to supervise project groups
- to participate actively in expert discussions

Of course, you will be appreciated as a partner or as a private supporting member of the TUM: Junge Akademie. This includes in particular

- Vour (company) name on the homepage of the TUM: Junge Akademie
- Your name on selected publications of the TUM: Junge Akademie as a supporting member

#### **Scholarship Holder**

The TUM: Junge Akademie scholarship program is open to all TUM students who are nominated by their School or Faculty or who submit an application including a recommendation by one of the professors of TUM. Students of HFF (Hochschule für Fernsehen und Film), ADBK (Akademie der Bildenden Künste), and HMTM (Hochschule für Musik und Theater München) are also invited to apply for the TUM: Junge Akademie. Apart from achievements during your studies, decisive criteria are creativity, community involvement, and willingness to take responsibility. Are you interested? Stay tuned for the next class of 2024 to apply by August 31, 2023.

You are eligible if you are

- enrolled at TUM, ADBK, HFF, HMTM or LMU
- one of the outstanding students of your semester
- eager to develop yourself
- highly interested in science and research
- not compromised in your educational performance by the TUM-JA membership



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