TUM: Junge Akademie

Research Reports 2019

TUM: JUNGE AKADEMIE 2010 - 2020

TUM: Junge Akademie

Research Reports 2019

Partner of

TUM Universitätsstiftung

Welcome to the *TUM: Junge Akademie*

In this booklet, the insights and final results of the 2019 project groups are presented, showcasing how our particularly talented students translated the call "Multimodal Science Communication" into tangible projects. Every year our students are challenged to sort and structure their ideas in order to move from general discussions and opinions to concrete projects, to move from the "Talk the Talk" to the "Walk the Walk" of systematic scientific investigation.

Our call "Multimodal Science Communication" addresses above all issues related to the question of how the various options of communicating scientific ideas can be combined in meaningful ways to optimize communications in their full breadth. This breadth ranges from providing the general public with an adequate understanding of scientific insights and of the complexity of society, through ensuring effective education in its different phases of individual learning cycles, to the sorts of high-level communication needed for professional collaboration in industry and science. When we developed the call in the advisory board of the *TUM: Junge Akademie* – long before Covid-19 – nobody could have imagined that it would become so topical in 2020: Without the use of new forms of multimodal communication, which have emerged from creativity fired by necessity, teaching would not have been possible in the COVID-19 crisis. The first experiences were quickly exchanged and evaluated, so that, despite some prophecies of doom in the early stages and with far more than 25.000 videos and a six-digit number of teaching sessions (seminars, exercises, lectures), we proved impressively in the summer semester 2020 that both students and lecturers at TUM could face the emerging challenges pragmatically and flexibly. The lecturers even "overtook on the right" and surprised the teaching theorists in the application of what were until then unexpected and unknown strategies for teaching effectively.

Of course there could now be the danger that current developments have also overtaken the project groups of the *TUM: Junge Akademie*, since the projects had been defined before the outbreak of Covid-19. In fact, the opposite is the case and the projects presented here are highly relevant, addressing key issues that are even more important than they were before the crisis:

- The export of research and teaching and the exchange between cultures (Africast), a topic which is fired by our Covid-19 experience with cross-continental teaching and examination and which suggests new dimensions in the mutual exchange of teaching;
- the communication process between science and society, involving all generations, young and old – a timeless topic which, while not at the center of attention during COVID-19, also holds great potential for dynamic new possibilities and experiences (Digital Enlightenment, MUC Trail);
- the improvement of forms and structures in the learning process and the interaction between teachers and students, in terms of metrics, feedback loops, student attention and consideration of individuality, which are central themes in the currently experienced transformation of teaching (EvaluaTUM, Quintessence, StudyStrats).
- And finally, the Freesearch group has reacted very proactively to the COVID-19 crisis and has adapted its topic towards support packages for students.

Why are we convinced of our format for the *TUM: Junge Akademie*? Why do we invest so much time in this format? We do so because we know that our excellent graduates will have the responsibility and the power in the future to identify socially disruptive processes and to proactively shape developments for the better – to understand, analyze and balance conflicts of interests, and to act as moderators and communicators. We thus consider it as particularly important to encourage our students to discuss difficult issues that require a transdisciplinary approach – ranging from psychology, over communication theory, politics, economics, information technology to the potential of arts and cross-links to history and philosophy.

We also want to encourage our students to identify their responsibility in relation to the expertise they acquire at TUM. More than before, the developments of the last few months have shown how important it is that those who possess knowledge and expertise take the initiative to clearly structure discussions, and do not shy away from challenging people who clearly lack expertise, but who nevertheless build on diffuse combinations and conspiracy theories that generate fear and can potentially trigger dangerous consequences.

Dear students: Be prepared for your future work, fueled by scientific analysis, creativity, commitment, good communication and a sense of responsibility arising from your expertise.

My sincere thanks to all the mentors, tutors, and former members involved in the projects. Their generosity of time, expertise, and friendly advice has been of enormous value to the project groups. Many thanks also to the TUM Board of Management for supporting the format, to the Managing Director Peter Finger and his team for their invaluable and highly professional guidance, and to the members of the Taskforces and the Board of Members for their creativity, devotion, and enthusiasm.

Enjoy reading this booklet and exploring the projects!

Yours,

Gerhard Müller
Senior Vice President Academic and Student Affairs

Dear TUM friends and associates,

Exactly ten years ago, the Technical University of Munich founded the “TUM: Junge Akademie” (TUMJA) as a scholarship program for exceptionally talented and dedicated students. Brought to life under the direction of Prof. Dr. Peter Gritzmann, former TUM Senior Vice President for Study and Teaching, it is now a firmly established part of our university.

TUMJA fosters the talent of TUM's most outstanding students and young alumni, creating an environment that allows them to bring their ideas to fruition. This time-proven format runs in the blood of TUM: Creative ideas turn into conclusive concepts, which come to life by the work of enthusiastic and interdisciplinary teams.

Students that become TUMJA fellows are tackling and solving real-life issues facing the world today. In order to pave their way they also take part in a comprehensive training program to acquire key soft-skills and support their personal development. In addition, the program has connected our students with a vibrant network of mentors such as young researchers, alumni of the TUMJA, faculty professors as well as TUM Emeriti of Excellence. However, the benefits of the TUMJA scholarships do not end with the students. The research done by the students finds a wide range of everyday applications: Based on their own analysis of pressing societal questions, they deliver highly sought-after answers to the woes of our lives. There are many outstanding projects launched by students of TUMJA, such as: VisiTUM, a program for college career counseling for high school students, as well as the Campus Run sporting event which is now a fixed date on the TUM calendar. Furthermore, the exceptional mentoring program "Buddy for Refugees" deserves mention, which helped more than 600 refugees adapt to their new home during 2015 and 2018. So far, TUMJA gave 70 propositions the creative space to develop their projects and – most importantly to the scholarship fellows – facilitate the steps to a measurable impact on our community.

The program accelerates our top students’ careers of which the alumni’s impressive CVs are living proof: Seven TUMJA alumni are already professors, and more than 80 percent are currently working on or have successfully completed a doctoral thesis. In addition to that, several alumni are also outstanding founders and managers in the private sector.

We are able to look back on a decade marked by the outstanding success of the TUMJA scholarship program. We are very proud of the entirety of TUM staff involved, among them our best and brightest faculty professors. I firmly believe that the gifted young minds of our university have the potential to power the engine of progress of our modern society.

My congratulations on ten years of TUMJA especially go to Prof. Dr. Peter Gritzmann, Prof. Regine Keller and Prof. Dr.-Ing. Gerhard Müller, the Senior Vice Presidents for Academic and Student Affairs, responsible for the successful development of this unique scholarship program.

Furthermore, 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 wish all TUMJA scholarship holders, alumni, friends, and sponsors three things: Curiosity, determination and most of all continued success!

Yours sincerely,

Thomas F. Hofmann
President

> “Never limit yourself because of
> others' limited imagination;
> never limit others because of your
> own limited imagination.”
> Mae C. Jemison

Table of Contents

Editorial 2
Greetings from the President 5

TUMJA Anniversary

TUM: Junge Akademie – Passion for Science 8
Benefit from exclusive Workshops 10
Creativity through Time Pressure? Insights from an Empirical Study 12
Contribute to the future of the program 14
Join our Network 16
Directors’ Point of View 18
TUM: Junge Akademie Community 22
Partner Universities 24
Where decisions are made 26
A Place to Meet 28

Directory

List of Scholarship Holders 32
List of Tutors 38
List of Supervisors 40

Projects 2019

🟦 Africast 44
🟩 Digital Enlightenment 70
🟦 EvaluaTUM 92
🟧 Freesearch 116
🟦 MUCtrail 138
🟦 Quintessence 158
🟦 StudyStrats 178

Highlights 2019 198

Projects in Prospect 2020

AppCycle 208
Clarify 210
EnterTrainment 212
Exfluenced 214
Exhibition Fish 216
Lacktivity 218

Taskforces 220
Taskforce CAP 223
Taskforce Event 224
Taskforce International 225
Taskforce Marketing 226
Taskforce Members 228
Taskforce Mentoring 229
Taskforce Symposium 230
Taskforce XP transfer 231

Our industrial partner 234

Imprint 239

WAHRHEIT 2.0
SYMPO_
SIUM

TUM: Junge Akademie – Passion for Science

The TUM: Junge Akademie aspires to promote their 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, beginning from substantiating their project idea to concluding it as a project report. Various workshops, such as for scientific and journalistic writing or project management, accompany the project work.

Not every project is a success, and sometimes it has to be modified along the way. That is also part of learning. However, numerous projects in recent years were so successful that other institutions adopted and continued the successful work.

In addition to project work, the scholarship of the TUM: Junge Akademie includes much more: An extensive supporting program with community-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.

Eighty fellows and over 500 alumni, mentors, and professors from four universities are part of the TUMJA community. The creativity of its members and the large community of highly motivated personalities shape the ten-year history of TUMJA.

We look forward to our community growing further over the next few decades.

Benefit from exclusive Workshops

“It's no drama if the project doesn't go according to plan.
It's a drama if the project manager doesn't know about it.” (Peter Hobbs)

As the scholarship holders of the TUM: Junge Akademie come from different faculties of TUM and its partner universities, they are used to working on a large variety of projects from their subject areas. For instance, an educational study is completely different from the development of a fitness app. Working together with students from other disciplines can be challenging. The organization within the team might be another difficulty, as there are neither managers nor hierarchies. To avoid dramas in the projects, the TUM: Junge Akademie offers project management workshops for its scholarship holders.

Scholarship holders gain a better understanding of their own role and that of their team colleagues in the project, learn to set SMART goals and to assess the timescale and dependencies of the individual steps. In multi-day workshops, former scholarship holders teach methods such as parallel thinking, core problem analysis, scientific work and effective communication, which the teams apply to their specific project idea.

Despite, or perhaps because of, the major upheavals in the Corona crisis, a virtual Zoom workshop was offered for the first time this semester in order to provide the teams with the necessary structure for their projects in these difficult times.

Dr. Matthias Lehner, Stefan Röhrl, Sabrina Schwarzmeier, Prof. Dr. Alexander Lang
Project Management Team

MEILENSTEINE
Themenfindung
UMSETZBARKEIT Umsetzung
PROJEKTPHASE
TURNING POINTS
NEBENPROJEKTE
WISSENSCHAFTLICHKEIT
TREFFEN
ORGANISATION
ZEITMANAGEMENT
ANWESENHEIT
REFLEXION
ORGANISATION
?
INT KTION
To Do Liste
Zeitstrahl
ROLLEN-VERTEILUNG
REGELN der ZUSAMMENARBEIT
KONFLIKTE/ KONFLIKTMANAGEMENT
BEZIEHUNGEN
Apps
TOOLS IM ARBEITSPROZESS
gemeinsamer Kalender
ZUSAMMENARBEIT
AUFGABEN - Verteilung - Verbindlichkeit
Kommunikation
Dokumentation (Protokolle)
Nützlichkeit
ENDPRODUKT
Learn

"Die Reise von Migranten wird für gewöhnlich als linearer Verlauf von der Heimat in das Gastgeberland dargestellt. Tatsächlich ist dieser Weg jedoch von Störungen, Unterbrechungen, Warten, Vertreibungen, Übergängen und Flucht geprägt."
RE
53

Act

Creativity through Time Pressure? Insights from an Empirical Study

TUMJA challenges its scholarship holders to develop a research project up from scratch in an interdisciplinary team. The projects focus on creative solutions on the edge of science and society.

Truly revolutionary ideas do not arise overnight. In contrast, common parlance also holds that “necessity is the mother of invention.” Today’s work environment seems to be driven by this necessity: We have to produce new products and solutions at an ever-faster pace. Moreover, we no longer develop new products and solutions individually but more and more as a team. So, how does time pressure affect our individual and team creativity?

Based on my research, the short answer is: “It is beneficial for us as individuals, but detrimental for our team.” I analyzed multisource data from 138 team members and 27 supervisors in student project teams – including teams of the TUM: Junge Akademie. In particular, my post hoc analyses indicate that time pressure may serve as a motivating stimulus to foster the individuals’ beliefs in achieving creative solutions — their creative self-efficacy — which led to higher individual creativity. On the other hand, an opposite effect occurred at the team level. Team time pressure complicated team knowledge-sharing, which in turn reduced team creativity.

Therefore, we should only allow ourselves to be put under time pressure if we can solve the required task on our own and it triggers our creative motivation. For tasks for which the team’s creativity is crucial, we should take time to share our knowledge with our colleagues and to inspire each other.

Niklas Dreymann
Scholarship holder, Year 2019

Contribute to the future of the program

All scholarship holders participate in a self-organized taskforce of their choice. The taskforces enable them to contribute their ideas and personal talents, and thereby shape the future of the program. On average, each taskforce meets twice a month to discuss and plan future activities. Besides this, group representatives meet regularly to keep each other updated. To work in one of the taskforces is an essential part of the scholarship program. The scholarship holders acquire skills related to the taskforce they joined, such as event planning, design, project management, and many more. By collaborating with scholarship holders from other projects and years, they expand their network.

> ***"I higly recommend the TUMJA scholarship, to learn how to work in multidisciplinary teams, because this is the future for sustainable successful projects serving our society."***
> Andrea Geipel, M. Sc.
> Research Institute for the History of Science and Technology, Deutsches Museum, Munic.

Taskforce Contacts, Alliances, Partnerships aims to generate funding, and establish and maintain a network of partnerships between scholarship holders, alumni, and companies.

Taskforce Event provides exciting events every semester, offers opportunities to experience a lot of different things, and get to know each other.

Taskforce International wants to create an intercultural exchange amongst students from international universities involved in similar projects as the TUM: Junge Akademie.

Taskforce Marketing aims to increase the brand image and recognition of TUMJA's interdisciplinary scholarship program.

Taskforce Mentoring designs a one-to-one mentoring program for current scholarship holders with TUMJA alumni.

Taskforce Members is responsible for all issues concerning the active members, alumni, and members-to-be, for instance, the application process.

Taskforce Symposia organizes the final event of each year – the yearly symposium.

Taskforce XP Transfer restructures the TUMJA Wiki, so the project groups and task forces can find and profit from the existing know-how and the experiences of all TUMJA members.

For more information on each of the taskforces, check out pages 220 – 231.

Welcome to Science Hack 2019
Kick-off Event
TUM
SCIENCE HACK 2019
december 7 - 8
SUSTAINABILITY
ja.tum.de/sciencehack
hosted by
Altair
BMW GROUP
Hubert Burda Media
itk
PIXIDA
WACKER

Impact

Forschungskontakte
Freude
neue Freunde

Connect

Join our Network

One of the great advantages of TUM: Junge Akademie is the extensive network it provides for its scholarship holders. It consists of over 600 active scholarship holders, alumni, various experts from industry and numerous professors, whose contributions and involvements vary within the program.

> ***„TUMJA is a great program to broaden one's perspective. It offers the opportunity to extend one's network and to work on various, impactful projects."***
> Prof. Dr. Nadine Kammerlander
> Chair & Institute for Family Business, WHU – Otto Beisheim School of Management

Tutors

Each project team is supported by two tutors during their scholarship. The tutor's purpose is to assist the team in team building and project work. They are the primary contact for any problems that might arise. As most of the tutors are alumni of the TUM: Junge Akademie themselves, they can guide the active members based on their experience and the networks they have already established. Furthermore, tutors can enrich the group's work by, for example, providing insights into career pathways and suggesting strategies for long project work or for contacting partners from academia and the wider economy.

Supervisors

Most supervisors of the TUM: Junge Akademie are professors from the participating universities, while some are also alumni with special expertise matching the project area of a team. In contrast to the tutors, the supervisors advise the team on the scientific aspects of their work. They provide support relating to the selected research question and to the research methods used by the group, as well as to how the group assures the quality of their work. They constructively scrutinize the project's aims and focus. Utilizing their far-reaching networks both inside and outside the university, they often help to promote the projects.

Experts from academia and other fields

The network of the TUM: Junge Akademie also includes professionals from different fields of expertise, who can sometimes be part of both academia and the wider world of business, science or industry. The scholarship holders can approach those experts with specific questions related to their proficiency or to ask for general guidance in overcoming problems.

Friederike Jungmann
Scholarship holder, Year 2019

Directors’ Point of View

Prof. Dr. Peter Gritzmann
Director of the TUM: Junge Akademie 2010-2011
Ab *ingenio ad excellentiam – From talent to excellence* was the founding concept of the TUM: Junge Akademie, and became its motto at its inception in 2010. The academy’s ongoing mission is to inspire and support outstanding and highly committed students to develop their potential beyond the boundaries of their fields of study.

This vision is symbolized by the logo: the TUM: Junge Akademie aims at allowing wings to grow, and encourages students to fly to new shores.

A key building block to further this goal was and still is an interdisciplinary one-year project in teams of about six students from different fields. Based on the expertise rooted in their main fields of study, the students should experience and reflect their role as experts in their subject in collaboration with fellow students from other disciplines, guided by a common project goal. Support included workshops on project management and leadership, motivation, rhetoric, and scientific writing, and, of course, mentoring from experienced academics.

The topics for the projects of the first cohorts grew out of initiating workshops where first ideas of the students were discussed and then made concrete. The themes included such diverse subjects as the *value of human life, self-sufficient community: a sustainable energy concept, urban mobility, and waste as a resource.*

Of course, there are many programs to support talented students. It is, however, this long-term project experience that is quite special to the TUM: Junge Akademie. It is self-evident that many challenges cannot be handled by just one discipline but need the collaboration of many fields. In order to be successful, the members of a team must be excellent in their field, bringing the knowledge, skills and way of thinking of their field into the group. But they also need to exhibit an openness to other ways of thinking, respect for other disciplines and some humility before the other’s potential and the problems which have to be tackled. While professional expertise is at the center of university studies and, at some point in their studies, students are very happy to have developed a professional identity, this “breaking its enclosures and mental confinements” again is not so easy. Defining, organizing and pursuing interdisciplinary work is – this was the feedback of all students – a sometimes painful iterative process with setbacks on many levels. But – as also all agreed upon – it is an extremely healthy and valuable experience which helped the students to “advance to a new level”.

We were grateful to the *Andrea von Braun Stiftung* for providing funds that enabled us to award prizes to the best projects, presented to a larger audience in a commemorative event. The prizes were not just a welcome additional motivation but actually allowed some subsequent implementation of the winning projects into practice so that they even developed some political impact.

But there is a lot more happening at the TUM: Junge Akademie: visits to companies and expositions, music and physical workout, discussions with experts on hot topics, or simply exchanging ideas in a fireplace atmosphere. Some of our first activities might even appear visionary or at least anticipatory today: at a visit to an international pharmaceutical company, we learned about the difficult, long and expensive process of developing new drugs and vaccines, or our dive into deep philosophical discussions with the LMU-Professors Harald Lesch and Wilhelm Vossenkuhl on artificial intelligence, potential machine-self-awareness and other controversial issues, years before the current hype.

Was it difficult to convince the president of TUM to fund this new (and somewhat experimental) initiative? No, not at all! Of course, from the very start, an evaluation of the program after three years was planned – and: the TUM: Junge Akademie does not just still exist but has developed into a flagship activity for capacity building at TUM. From the very beginning, TUM: Junge Akademie benefitted from being close to the management board of TUM: By its statute, the director is always the Vice President for Academic & Student Affairs. Also, a “warm start” was facilitated through a somewhat differently oriented and much smaller predecessor program "Experienced Ways into Research" whose heads, two Emeriti of Excellence became the first honorary members of the new TUM: Junge Akademie.

In the course of time, the TUM: Junge Akademie developed further. Based on the increasing experience and the constant feedback of all participants and partners, the program is constantly adjusted to further the benefit that a membership in the TUM: Junge Akademie brings. After all, it is a great distinction to be part of it, but also a lot of work as the program is not based on passive consumption but on “growing through action.” Ten years after its founding it seems unanimously clear: the TUM: Junge Akademie is a success story.

Prof. Dr. Regine Keller
Director of the TUM: Junge Akademie 2011-2014
To this day, I can still remember individual conversations with the talents of the TUM: Junge Akademie. It was always an inspiring exchange of ideas with young academics who showed a lively interest in the progress of our technical, scientific, but above all, social challenges far beyond their own discipline. When I took over the academy from my predecessor Peter Gritzmann in 2011, this first epoch already represented a well-established talent promotion within the TUM. The first years had successfully completed their projects, while others were still in the middle of researching special tasks. I was curious to see what kind of people I would be dealing with. Even during the annual admissions weekends, which were accompanied by intensive interviews with the applicants, I was amazed at the diversity of the talents. The best grades of their year were not only the top candidates in their subject but people who were highly committed to other areas of life. Whether it was the leadership of youth groups since their school days, tutoring, voluntary fire brigade, sports, or musical group work. In almost all cases, social commitment was highly developed. I often wondered where these talented young people, apart from their outstanding academic performance, found the time to carry out all these activities. All of them seemed to have so much capacity: purely dealing with the study content was not satisfactory, and willingness to deal with a wider field was the driving force for applying to the TUM: Junge Akademie. Conversely, of course, there were also expectations. In contrast to everyday student life, there was the desire to be confronted with topics at the TUM: Junge Akademie that the applicants expected to provide impulses for their own studies, but also to be allowed to work on socially relevant topics – something that many students had missed in their own studies. In the second epoch of the TUM: Junge Akademie, this fact led us to the decision that the supervising professors should not make the selection of topics, but that the students themselves should propose the spectrum of projects to be worked on in an initial workshop. It soon became clear that many of the projects we wanted to work on had a major social aspect, which was extremely important to the students. They wanted to do research on something that had social relevance. The project results of the second year were finally presented in a first project book. The chosen topics were broadly diversified and covered current concerns of our environment and society. The projects dealt with questions of mobility which led to the development of an app for spontaneous carpooling, the challenges of the energy turnaround, the requirements of an information policy with regard to current genetic engineering, or questions of resources with the focus on a conscious use of water, as well as the idea of biocompatible packaging and the topic of regionality in trade. The project groups were supervised by university teachers and young alumni of the TUM: Junge Akademie. Four professors were involved in supervising a project group in both the first and second year. The emeritus professors, especially the Emeriti of Excellence, made a very valuable contribution to the supervision of

the project groups and the personal mentoring of the members of TUM: Junge Akademie from the very beginning. Their supervision is highly appreciated by the members and deserves high recognition. They are an important part of the TUM: Junge Akademie.

It was by no means always a matter of course to promote the format of the TUM: Junge Akademie at the TUM, and so, even during my term of office as Director, I had to convince the university management of the usefulness of the program time and again. In this context, it was gratifying that it was possible to receive funding from the University Foundation over three years starting in 2013 with 50,000 euros per year each. After the implementation of the first years, it was also necessary to readjust the orientation of the TUM: Junge Akademie at various levels. Starting in 2013, information events were held for nominees, and the active time of the students was reduced from 5 to 3 years. Honorary membership was introduced in the same year: Prof. Hock, Prof. Gerhardt, Christoph Niedermeier, Martin Rothbucher, Andrea Geipel. From 2014 on, the Board of Members will be founded as a representative of the scholarship holders to co-determine the processes within the TUM: Junge Akademie. It elects delegates for the Advisory Board for the first time.

At the end of my time with the TUM: Junge Akademie, a first call "Campus of the Future" was issued... in other words: It continued and with new élan by my successor Gerhard Müller.

Prof. Dr.-Ing. Gerhard Müller
Director of the TUM: Junge Akademie 2014-today

"Logic will get you from A to B, imagination will take you everywhere" (Albert Einstein). Inevitably, especially in the technical disciplines, there is a strong focus in training on direct problem-solving skills based on logical connections. This is one of the reasons for the enormous success of the transfer of scientific and engineering findings into the reality of life in societies with an impressive impact on the well-being of people. Nevertheless, to quote Albert Einstein once again: "We can't solve problems by using the same kind of thinking we used when we created", we must not allow ourselves to be blinded by the momentum of the success of approaches to thinking and problem-solving, and we must reflect and discuss possible consequences intelligently. To do this, we need a generation of high performers who, despite all the absolutely necessary professional depth, are also capable of a change of perspective and exchange with other disciplines.

Among the most stimulating and enjoyable activities of a university teacher are discussions with and the accompaniment of young talents, who prepare themselves in a highly reflective manner for their future and the shaping of the world. It is inspiring when students from different faculties, who will later shape the world from different perspectives and with different skills, come to grips with the realization that responsible action cannot simply be projected onto clearly defined tasks with pre-structured solutions. It is great to observe when they are keen to deal with societal challenges and interrelationships and contribute their specialist knowledge and perspectives to a holistic view of the world within an interdisciplinary team. The TUM: Junge Akademie is designed to provide herefore a breeding ground in a scientific environment. This works: High-performing students identified by their faculties do not need to be motivated by personal monetary or material support for the time, energy, and commitment they bring to the academy. No, the professional support provided by top-class TUM scientists, the support of professional work in interdisciplinary teams with binding, generally very complex projects, the new experience gained from cross-references to other ways of thinking and approaches to problem-solving, and the inspirations from the gathering of bright and fiery minds creating a special unique ecosystem and spirit fosters the attractiveness of the program. In this respect, the TUM: Junge Akademie considerably differs from other scholarship programs.

Moving from talking the talk to walking the walk... The societal challenges that are widely discussed today are usually difficult to grasp from isolated perspectives of individual disciplines. Under no circumstances should they be dealt with from distinctive individual standpoints. They require an interdisciplinary view in all aspects; the identification of questions, their transformation into strategies for dealing with them, and, finally, the communication within a society. Discussing and developing the instruments for this requires more than just talk the talk, but rather the translation of general challenges into questions and tasks to be able to meet them. Every year it is exciting anew how a structured individual and then group-spanning brainstorming process is sorted and transferred into concrete tasks that can only be used as the basis of commitment, discipline, diligence, and scientific methods. In this way, the fluid talk the talk is transformed into structured walk the walk with goals, solid scientific methods, and concrete results, i.e. into difficult concrete problems.

Scholarship holders of 2012

Over the past six years, we have tried through various measures to further strengthen and support this process. To this end, we have placed calls in our Advisory Board – deliberately very broadly defined and general – which address the fundamental challenges and mechanisms of human interaction, of progress and the necessary transformations, from decision-making processes to dealing with transformations, from the communication and reception of ideas via multimedia communication channels to the interweaving of the dimensions of technology and art. We have expanded TUM: Junge Akademie to include students from the Academy of Fine Arts, the University for Television and Film, and the University of Music and Performing Arts to integrate new perspectives. We have taken on concrete social challenges that immediately required an overarching view, such as the Buddies for Refugees Program, which was launched promptly in 2015 in the context of the high number of refugees, with an enormous outreach, where interaction with psychologists, social scientists, the department of medicine, the religious university communities and the training of student buddies became immediately tangible as a walk the walk. We furthermore switched from German to English completely, unnoticed and just like that, to benefit more from the perspectives of our international students. In addition, our selection process was further developed in a highly professional manner and further aligned with our goals. The success? Record numbers of applications for this extracurricular format, 85% of our scholarship holders have continued their academic work in a doctorate. TUM: Junge Akademie enjoys a sound visibility in the life of our city.

Challenges for the TUM: Junge Akademie? Of course, there is the scientific aspect in particular, in the balancing act with the very broad calls. At a Technical University, scientific excellence is demonstrated much more clearly if questions and their solutions are further developed in a narrowly defined specialist context. In the case of broadly comprehensive questions in very large interdisciplinary solution areas, there is sometimes a lack of deep scientific drilling. In addition, the systematic approach to obtaining and substantiating findings is incomparably more complex for students and also for peer evaluation. We have therefore initiated in the TUM: Junge Akademie the format of a scientific final conference instead of a graduation ceremony, new formats of the yearbook, in which we expect a scientific report on the results, a reflection on the process of dealing with open solution spaces and a communication for societal stakeholders and a more stringent scientific support in the project work.

TUM: Junge Akademie remains a field of experimentation and a pilot facility for TUM to optimally support future important personalities in our society in their preparation for a holistic view of our challenges and interdisciplinary solution strategies. "Logic will get you from A to B" is a central and timelessly important pillar in our education, "imagination will take you everywhere" is to be further promoted in a talent-oriented way through the TUM: Junge Akademie.

We are delighted about the young talents, and I am personally pleased that I was able to accompany this program for six years. My sincere thanks go to my two predecessors Peter Gritzmann and Regine Keller, for the sustainable implementation and development of this very special support program, to the University Foundation and the University Board for their generous support of the format, to Peter Finger and his team for their intelligent supervision of the program, and to all those who run the program content: the mentors and tutors for their competent support of the scholarship holders, the colleagues on the Advisory Board for the design and continuous transformation of the format and, above all, to the scholarship holders, who, through their actions and their feedback help us to design the program and further develop it for future generations.

TUM: Junge Akademie Community

Sarah Abelen, Marina Able, Caroline Adam, Dina Aladawy, Julian Albers, Fabian Alt, Karim Aly, Meike Marie Amma, Florian Andres, Julia Angerer, Severin Angerpointner, Lena Appel, Philipp Assum, Johannes Assum, Christiane Aumüller, Magdalena Bader, Laura Ballentin, Paul Bandow, Holger Banzhaf, Andreas Barthelme, Marcin Bartkowiak, Katja Bartsch, Veronika Bauer, Maximilian Bauer, Philipp Bauer, Robert Bauer, Sandra Baumgardt, Maria Baumgartner, Lorenz Baumgartner, Michael Bay, Christina Bayerl, Michael Alexander Becker, Felix Behr, Laura-Sophie Behrends, Pascal Berberat, Sonja Berensmeier, Silvia Bergt, Mario Berk, Maren Bertling, Diana Beyerlein, Deniz Avni Bezgin, Thomas Bickel Haase, Gunther Bidlingmaier, Benedict Biebl, Maximilian Biebl, Erwin Biebl, Alexander Biederer, Eva Maria Biehl, Julian Biendarra, Julian Sebastian Birkmaier, Altan Birler, Florian Bißbort, Sebastian Bittl, Thomas Blasi, Artem Bliznyuk, Karlis Blums, Maximilian Bode, Beatrice Boekstegers, Philip Böhm, Bernhard Johann Bohn, Alexander Böhner, Youssef Bouguerba, Fabio Bove, Christian Bozsak, Len Brandes, Matthias Brasse, Nino Bratovic, Sarah Lena Braun, Benjamin Braun, Artur Braun, Sarah Braun, Felix Braun, Thomas Bredl, Annemarie Breu (geb. Hofmann), Klaus Bruckdorfer, Matthias Brugger, Andreas-David Brunner, Theresa Buberl, Christopher Buchmann, Stefan Büchner, Vanessa Buchweitz, Thomas Burger, Martin Buss, Maximilian Butz, Yinshui Chang, Patrick Ferdinand Christ, Panagiotis Christou, En-Hsin Chung, Niccolò Ciarlini, Michael Clormann , Renato Coppi, Maria Elena Corella, Andrei Costinescu, Pablo Cova Fariña, Milan Cupac, Marcel Dann, Ario Dastmaltschi, Miriam Däubler, Walter Timo de Vries, Nicolas Dechamps, Monica Déchène, Christoph Dehner, Samuel Detzel, Klaus Diepold, Florian Dietz, Matthias Dodenhöft, Jens Dodenhöft, Valerie Domcke, Niklas Dreymann, Chengran Du, Georg Dürr, Carl Ebbinghaus, Simon Eberle, Christopher Ebert, Markus Ebert, Dominik Ebi, Lukas Egerer, Johannes Ehrmaier, Anna Verena Eireiner, Natalie Kira Eisenhut, Omar Eldeeb, Rishith Ellath Meethal, Jana Ellegast, Fabian Elsner (geb. Ballweg), Stefan Engels, Markus Englert, Wolfgang Enzi, Nadine Erhard-Egeler, Anna-Lena Fackler, Georg Färber, Ignacio Farias Hurtado, Christian Faßbender, Johannes Feldmaier, Carlotta Ferri, Markus Feuchtinger, Peter Fierlinger, Fabian Finger, Meric Firat, Julian Fischer, Victor Fleischer, Tilman Flock, Hans Förstl, Christiane Frank, Nicolas Frank, Dominik Bastian Frank, Fabian Franke, Veronika Franz, Christian Franzmann, Fritz Frenkler, Daniel Frey, Verena Friedl, Anja Friedrich , Frank Frieß, Christoph Frisch, Stefan Froschmeir, Felix Früchtl, Gabriele Fruth, Bertram Fuchs, Sonja Fuchs, Roland Fuchsberger, Christiane Gabelsberger, Marieclara Gadebusch Bondio, Anja Gain, Simon Gandorfer, Christos Gazanis, Julian Geiger, Andrea Geipel, Markus Geiser, Jürgen Geist, Anna Gensbaur, Paul Gerhardt, Matthias Geuß, Philipp Geyer, Franz Xaver Gillmeyer, Elisabeth Gleisinger, Barbara Gleißl, Vanessa Glunz, Maximilian Goblirsch-Kolb, Alexander Goedel, Dennis Goldner, Vladimir Golkov, Vadim Goryainov, Stefan Göttl, Reiner Gradinger, Ramses Alejandro Grande Fraile, Christian Grätz, Thomas Grauvogl, Sonja Grill, Peter Gritzmann, Friederike Groschupp, Josef Groß, Fabian Gruber, Harry Grundmann, Richard Gruner, Paul Grünke, Martina Gschwendtner, Fabian Güra, Fabienne Haas, Danilo Hackner, Juliane Hafermann, Bernhard Häfner, Stefan Hager, Patrick Haider, Sebastian Hambauer, Alexander Hanel, Christoph Hartlmüller, Sophia Hasbach, Florian Häse, Matthias Haslbeck, Michael Haubenschild, Franziska Hauler, Daniela Häusele, Hubert Hautmann, Liu Weng Hayden, Max Leon Hechler, Hendrik Heenen, Frederik Heetmeyer, Alexander Heilmann, Andreas Heimfarth, Rupert Heindl, Alexander Heinecke, Jeremias Heinrich, Christoph Heinrich, Simon Heinze, Tobias Helbig, Maximilian Held, Michael Hell, Florian Henke, Florian Henkes, Johannes Herms, Daniel Hernández, Jennifer Herrmann, Simon Herzog, Lisa Herzog, Martin Hetzl, Elisabeth Hobmaier, Bertold Hock, Katharina Marliese Höfer, Laura Hoffmann, Franz Hofmann, Karin Höglmeier, Philipp Ekkehard Hölzenbein, Kailun Hong, Anja Hoppenkamps, Madeleine Hotter, Ho Huang, Xinyi Huang, Annalena Huber, Dennis Huber, Florian Hübler, Marie-Theres Huemer, Sabine Hug, Philipp Hulm, Philipp Hupp, Linus Huss, Saskia Hutschenreiter, Konrad Hütten, Dominik Irber, Rudolf Jakob, Lisa Janker, Sebastian Jarosch, Joel Jäschke, Eike Jessen †, Werner Jiang, Lea John, Jannika John, Maximilian Juna, Lukas Jung, Friederike Jungmann, Thomas Just, Johannes Kaesmacher, Stefan Kahler, Eva-Maria Kainz, Jakob Kaiser, Matthias Kaiser, Florian Kaiser, Sebastian Kaltenbach, Nadine Kammerlander, Alexander Karollus, Martin Kaumanns, Anne Kearnes (geb.Hulitschke), Eskander Kebsi, Hannemor Keidel, Peter Keil, Kevin Keim, Christian Keimel, Regine Keller, Christina Kendler, Maximilian Kern, Andrea Kick, Georg Alexander Kiener, Josef Kimberger, Andreas Kirschner, Paul Klar, Manfred Kleber, Kyra Kleine, Sarah Klitzke, Carolin Juliana Klose, Sarah Kluge, Tilman Knopp, Jan Kochanowski, Thilo Kögl, Viktor Kölzer, Stefan Markus König, Marlies Gwendolyn Köpke, Wiebke Köpp, Phillip Koppitz, Erik Kordt, Daniel Körner, Gwenael Kosider, Kathrin Maria Kostorz, Tim Kratky, Johann Kratzer, Andreas Kratzert, Luisa-Maria Kraus, Michael Krautblatter, Malte Kremser, Pascal Kriesche, Daniela Krings, Franziska Kruger geb. Ortner, Maria Kuhn, Johaina Kullab, Ann-Kathrin Kummer (geb. Straub), Beate Lang, Jan Lang, Johannes Lang, Alexander Lang, Bettina Langer, Frank Latsch, Peter Latz, Jaimee Lau, Alfred Laubereau, Tim Lauer, Sebastian Laumer, Vivien Lechner, Marvin Lechner, Stefan Lehner, Matthias Lehner, Konrad Marek Günter Leibrandt, Sebastian Leicher, Henry Lindner, Dominik Lisowski, Lena Litzenburger, Kilian Lupp, Melissa Lutgardo, Sabine Maasen, Mohammad Youssef Mahfouz, Roland Maier, Klaus Mainzer, Sebastian Mair, Florian Männer, Dennis Manteuffel, Rebeca Marichalar Quezada, Philipp Marzak, Thomas Mathes, Jan Mathony, Aikaterini Mavroudi, Ernst Mayr, Jara Meier, Christoph Meier, Felix Meier, Frank Meinl, Philine Meister (geb. Donner), Liqiu Meng, Marius Merkle, Rebecca Metzger, Daniel Michalovics, Frank Mildner, Alina Minth, Matthias Mitterhofer, Haruko Miura, Alwine Mohnen, Michael Molls, Nikolai Morin, Sebastian Mühlbauer, Gerhard Müller, Ruth Müller, Nitish Nagesh, Beate Neu, Thomas Neubauer, Joshua Sharon Neumann, Daniel Neumann, Matthias Neumayer, Jessica Neußer, Sebastian Neusser, Christoph Niedermeier, Felix Niemeier, Janna Nikonov, David Noachtar, Christine Nöhmeier, Yuki Nojiri, Andreas Noll, Annette Noschka-Roos , Felix Nuscheler, Christian Obermeier, Benedikt Josef Oberndorfer, Maike Offer, Miriam Ostermaier, Alexander Otti, Himanshu Panandikar, Jonas Papazoglou-Hennig, Judith Paripovic, Maximilian Passek, Matthias Passek, Florian Paukner, Philipp Paukner, Joel Pereira, Carla Pernpeintner (geb. Zensen), Hannes Petermeier, Sophie Petersen, Winfried Petry, Philip Petzoldt, Jennifer Pfefferkorn, Friedrich Pfeiffer, Kerstin Pfister, Christoph Pflügler, Julian Pfrombeck, Manuel Johannes Philipp, Carlos Piedrafita Alvira, Sabine Pircher, Nikolaus Pöchhacker, Julia Poliak, Ingmar Polte, Anna Pontz, Sascha Posanski, Daniela Pothmann, Nelly Prechtl, Xenia Priebe, Leonard Przybilla, Shiyu Qiu, Christina Raasch, Lukas Raith, Andreas Rauch, Bernd Redmann, Simon Rehwald, Michael Reichert, Stefanie Reiffert, Barbara Reiner, Robert Reiser, Kristina Reiss, Bettina Reitz, Julian Renz, Tobias Renz, Pascal Resch, Felix Richter, Konstantin Riedl, Simon Rieß, Martin Riester, Philipp Rinner, Konstantin Ritt, Eva Ritter, Dennis Röcker, Florian Röhrbein, Stefan Röhrl, Nicolas Röhrle, Narek Rostomyan, Martin Rothbucher, Jonas Ruchti, Azzurra Ruggeri, Peter Russer, Erich Sackmann , Andreas Sauer, Paul Andrei Sava, Marouane Sayih, Katharina Schaar, Olga Schäfer, Philipp Maximilian Schäfer, Martin Schafhirt, Jakob Schardt, Markus Schatz, Jan Luca Scheerer, Jakob Scheffels, Leah Schembs, Anna Schendzielorz, Michael Schermann, Hanna Scheuermann, Jürgen Scheurele , Kristina Schick, Katrin Siwanto Schiefenhövel, Maximilian Schiffer, Carolin Schimmer, Dominik Schindler, Andrea Schlegel, Christopher Schlenk, Michael-Georg Schmeidl, Eva-Maria Schmid, Manfred Schmid †, Anna Schmidt, Fabian Schmidt, Elisabeth Maria Schmidt, Fabian Schmitz, Manuel Schneider, Christine Anna Schneider, Christina Schöberl, Philipp Scholl, Sophia Schreiber, Maximilian Schreieck, Kristof Schröder, Christoph Schroth, Alexander Schubert, Sebastian Schuon, Laura Schütz, Max Schütz, Florian Schwaiger, Sophie Schwarz, Sabrina Schwarzmeier, Felix Schweighofer, Daniel Schwinger, Lea Sophie Seier, Franz Seitz, Albulena Selmani, Martin Seltmann, Maryna Shcherbak, Mohamed Shoeir, Paul Sieber, Sebastian Siegel, Lea Luka Sikau, Ferdos Sililo-Simon, Arthur Singer, Johannes Sinnhuber, Annkatrin Sommer, Jasmin Sowa, Patrick Sowinski, Gernot Spiegelberg, Matthias Spiegl, Mareike Spindler, Tobias Spöttl, Nicola Stadler, Tobias Stahl, Matthias Stahl, Andreas Steer, Simone Stegbauer, Johannes Peter Steidl, Simon Stelzl, Gertraud Stocker, Stephanie Alice Stockert, Daniel Straimer, Julian Straub, Ann-Kathrin Straub, Lisa Straußberger, Patrick Strobl, Axel Stürmer, Paul Stursberg, Juan Esteban Suarez, Andreas Suhrer, Eva Sum, Florian Surek, Elena Denise Tangocci, Mehmet Ali Taş, Maryam Tatari, Philip Maximilian Teichgräber, Nikolas Tekles, Carolin Thiem, Paul Thillen, Florian Tichy, Stefan Tippelt, Andreas Tomzig, Katrin Alexandra Töpner, Maximilian Totzauer, Victoria Treßel, Michael Trimpl, Oliver Trinchera, Katharina Tropschuh, Julian Trummer, Cora Uhlemann, Jonas Unterholzner, Daniel Urban, Valentina Ustinova, Samuel Valenzuela, Annika Cecilia Vernbro-Ravindren, Michael Vetter, Andreas Vietze, Ann-Christin Villegas, Bruno Villela Pedras Lago, Birgit Vogel-Heuser, Adrian Vogelsgesang, Christine Vogg, Nikolaus Volk, Benedikt Vollmann, Andreas Volmering, Jurij Leonard von Aster, Madlaina von Hößlin, Johannes von Stetten, Jana von Trott zu Solz, Elisabeth Wacker, Maximilian Wagner, Katharina Johanna Wagner, Alexandra Wagner, Youssef Walha, Tobias Wauer, Lena Weber, Dawei David Wei , Kai Weide, Andrea Susanne Weiller, Robin Weiß, Konrad Weiss, Sebastian Weiß, Stefanie Weiss, Isabell Welpe, Moritz Werb, Dominick Werner, Jeremias Widmann, Manuel Wiesche, Patricia Sophia Wild, Wotan Wilden, Peter Wilderer, Rupert Wildhofer, Anna Wittkowski, Maximilian Wittmann, David Wittmann, Sandra Witzgall, Susanne Witzgall, Stefan Wocheslander, Konstantin Matthias Paul Wolf, Justus Wolf, Stephan Wolf, Daniel Wolf, Tobias Wörl, Milena Wörsching, Johannes Wüllenweber, Stefan Wurster, Yushu Yang, Béatrice Zahn, Sebastian Zäpfel, Junianna Zatsarnaja, Mira Stephanie Zeilberger, Sophia Zeppenfeld, Datong Zhou, Yize Zhuwu, Benedict Zillinger, Alexander S. Zink, Matthias Zipper, Martin Zirngibl, Sebastian Zirngibl, Nina Zuber, Florian Zuleger

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.

In line with the one-region concept of the TUM excellence strategy motion, the network is set to grow further in future years.

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 MUSIK UND THEATER
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.

Where decisions are made

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. It primarily decides on the medium to long-term strategic and organizational issues of the TUM: Junge Akademie. Since 2016 the President of the University of Music and Performing Arts Munich, Prof. Bernd Redmann, and the President of the University of Television and Film Munich, Prof. Bettina Reitz, have further enriched the collaborative nature of the Advisory Board. The strategic themes include in particular the purpose and direction of the TUM: Junge Akademie 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. The Advisory Board also discusses proposals from the Board of Members. Besides, 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 the submitted project ideas.

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

Scholarship holders
Saskia Hutschenreiter
Dr. Matthias Lehner
Beate U. Neu
Jonas Ruchti
Sabrina Schwarzmeier
Paul Sieber

Professors
Prof. Dr. med. Pascal Berberat, TUM School of Medicine
Prof. Dr. Sonja Berensmeier, TUM Department of Mechanical Engineering
Prof. Dr. Sabine Maasen, Munich Center for Technology in Society
Prof. Dr. med. (em.) Michael Molls, Spokesperson Emeriti of Excellence
Prof. Dr. Bernd Redmann, University of Music and Performing Arts Munich
Prof. Bettina Reitz, University of Television and Film Munich

Board of Members
A board of members for the members: This is the mission of the members' council of the TUM: Junge Akademie. Each project group and each Taskforce sends one representative to the periodical meetings to keep their peers up to date, discuss ideas, give advice, and support each other to improve and further develop the TUM: Junge Akademie. Besides the regular visitors, all members and alumni are invited to join and contribute their experiences and opinions. The meetings are intended to offer a platform to synchronize the different groups and people and to achieve lively cooperation and synergy.

The Board of Members elects six student representatives to the Advisory Board. By the integration of the Board of Members into the Advisory Board, the scholarship holders can actively participate in the decision-making process and thereby represent their interests. Proposals for changes in the scholarship program are handed to the Advisory Board, the director, and the office team. Together with the board, the scholarship holders are encouraged to take action and implement these changes.

Our vision is to become more democratic and event-driven. Hence, we are planning a retreat, in which we overthink and re-discuss the Board of Members' aim and mission statement, to better structure future meetings and life at the TUM: Junge Akademie. The board is flexible and keeps the discussion time to a reasonable level, which is necessary due to the increased number of project groups and Taskforces. A code of conduct ensures the culinary supply of each meeting.

Speakers
Stefan Röhrl, Research Fellow at Chair of Data Processing
Elena Tangocci, Research Fellow at Chair for Teaching
and Learning with Digital Media

A Place to Meet

The original TUM: Junge Akademie base was the other room next to where the current office is now. It was also the place at which we spent most of our time. If you visited the office during the day, you would always be welcomed by Peter and Maria's energetic greetings and big smiles. This optimistic and positive atmosphere was absolutely one of the reasons I spent so much quality time at the TUM: Junge Akademie. It does not matter who you are and what kind of crazy ideas you have. You are always welcome to come here and share your ideas. My teammates and I spent a lot of time here. During our time at the TUM: Junge Akademie, countless discussions and conflicts occurred in the small kitchen behind the office where we met each other regularly. I always thought twenty months for a project was way too long, but I realized in the end that without this amount of time, we would probably not have become who we are today and achieved what we have now. I will never forget this, and I will always be grateful to have experienced and learned all I have in such a place full of hope, optimism, and friendliness.

Ho Huang
Scholarship Holder, Year 2019

Directory

List of Scholarship Holders 32
List of Tutors 38
List of Supervisors 40

List of Scholarship Holders 2019

Altan **Birler**
Freesearch
Informatics

For my team, I made sure technology was a tool rather than a hindrance.

Simon **Gandorfer**
Quintessence
Physics

I enjoyed the broad mixture of tasks: Fixing our goals and the research question, followed by two case studies, the implementation of the project and its analysis.

Sophia **Hasbach**
Quintessence
Sport and Health Sciences

At TUMJA I learned a lot of valuable lessons about scientific work and working in a team that I am sure will stay with me for a long time.

Ho **Huang**
Digital Enlightenment
Sport and Health Sciences

While our decisions might not have always been perfect, they underwent countless discussions to eventually become the best result of everyones ideas.

Xinyi **Huang**
Digital Enlightenment
Chemistry

A stressful but meaningful life experience.

Karlis **Blums**
Freesearch
TUM School of Life Sciences
Weihenstephan

Working in a highly interdisciplinary team gave me the opportunity to learn and experience problem solving from different perspectives. Thanks to my teammates!

Niklas **Dreymann**
MUCtrail
TUM School of Management

Working in a open-minded team, developing something innovative that helps people – that is what the TUMJA meant to me.

Stefan **Engels**
EvaluaTUM
Mathematics

During the inspiring, challenging, and fun time at TUMJA, I have improved to work across national, professional, and social borders.

Daniel **Frey**
Quintessence
Chemistry

Realizing and evaluating a study has been an exciting journey. I acquired new knowledge and skills, especially in project management and academic writing.

Dennis **Huber**
Quintessence
Chemistry

I truly appreciate that I was given the opportunity to establish a fascinating and sustainable project together with a group of awesome people.

Saskia **Hutschenreiter**
Quintessence
TUM School of Management

Growing from an idea to a scientific work in great demand – I appreciate every second at TUMJA, all the opportunities gained and most of all my team mates.

Lea **John**
StudyStrats
Sport and Health Sciences

During my time at the TUMJA I have learned a lot both professionally and personally.

Friederike **Jungmann**
StudyStrats
TUM School of Medicine

The last two years were an amazing time. Surpassing myself in the course of challenges but also by spending time with my team, I learned a lot.

List of Scholarship Holders 2019

Alexander **Karollus**
Freesearch
TUM School of Life Sciences
Weihenstephan

Finding the right idea can be challenging, but much can be learnt also from supposed dead ends.

Kilian **Lupp**
StudyStrats
TUM School of Life Sciences
Weihenstephan

Working on such an interdisciplinary project did not only enrich my scientific skills, but I also got the chance to collaborate with a talented group of people.

Rebeca
Marichalar Quezada
Digital Enlightenment
TUM School of Management

TUMJA has allowed me to create a project together with students from 4 different continents – changing my mindset and helping me to keep my feet on the ground.

Marius **Merkle**
Africast
Munich School of Engineering

Heading Taskforce Mentoring we achieved to double the number of mentees and mentors. At Africast, I did a podcast with a Ghanean student and a professor of TUM.

Nitish **Nagesh**
MUCtrail
Electrical and
Computer Engineering

As an international student, I had invaluable intercultural experiences while working on a project about imparting knowledge related to climate change in a fun way!

Jan **Kochanowski**
Freesearch
Physics

Getting inspired by the passion of great peers and learning together through a scientific approach summarizes my great time at the TUMJA, which I am grateful for.

Johaina **Kullab**
MUCtrail
TUM School of Medicine

As a young person you have visions for our future, the wish for a change. TUMJA brought creative and committed souls together and gave us the chance to do so.

Jaimee **Lau**
Africast
TUM School of Governance

Working in a diverse and motivated team on a socially relevant project was a unique opportunity to think outside of the box.

Stefan **Lehner**
EvaluaTUM
Informatics

During the two years I got a unique chance to adjust the evaluation system of TUM, and to enjoy a broad program in an excellent interdisciplinary community.

Beate **Neu**
MUCtrail
TUM School of Medicine

For good results you need more than just intriguing ideas and eager teammates: perseverance and a strong sense of responsibility are equally important.

Jessica **Neußer**
MUCtrail
TUM School of Life Sciences
Weihenstephan

I am proud to be part of a team, which created a unique and sustainable project, our MUCtrail.

Jonas
Papazoglou-Hennig
Quintessence
Mathematics

Working on a project that is based on research and held to a scientific standard has been an invaluable and extremely rewarding experience.

Judith **Paripovic**
EvaluaTUM
Civil, Geo and
Environmental Engineering

Our project was full of challenges, providing learning possibilities: Communication differentiation, working with a team all over Europe and establishing new concepts.

List of Scholarship Holders 2019

Pascal **Resch**
EvaluaTUM
TUM School of Education

I had a great time while working in our highly motivated team! Confident that our results and suggestions will have a great impact on the evaluation process of TUM.

Stephanie Alice **Stockert**
Freesearch
TUM School of Management

My time at TUMJA showed me what it means to work in a team successfully.

Elena Denise **Tangocci**
StudyStrats
TUM School of Education

A challenging and enjoyable time, in which we developed ourselves and grew together into an effective team.

Samuel **Valenzuela**
StudyStrats
Informatics

Spending time with my project group was a lot of fun! My favorite parts were the evenings at the seminar weekends as well as our trip to Berlin as a team.

Bruno **Villela Pedras Lago**
Freesearch
Chemistry/Mechanical Engineering

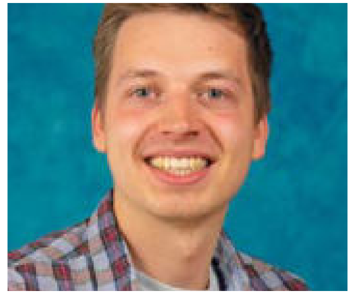
My time at the TUMJA has been full of obstacles and personal growth. Working with students from various majors, I learned applying my strengths.

Dominik **Schindler**
Freesearch
Civil, Geo and
Environmental Engineering

Interesting, challenging journey that I am glad I got to experience.

Paul **Sieber**
EvaluaTUM
Civil, Geo and
Environmental Engineering

Challenges give the opportunities to learn. TUMJA presented me with many challenges and helped me to learn from them.



Patrick **Sowinski**
Africast
Electrical and
Computer Science

Our 20-month project gave a me a new perspective on how to handle long-running projects. It was also great to meet people from different cultures.

Tobias **Spöttl**
Freesearch
Campus Straubing for
Biotechnology and Sustainability

The TUMJA taught me how to work in a interdisciplinary team, to solve problems and gave me great opportunities to extend my horizon and experiences.

Maximilian **Wagner**
Freesearch
TUM School of Governance

My TUMJA experience was riddled with new things and valuable lessons, with such a high degree of freedom and support, for which I am very grateful!

Katharina Johanna **Wagner**
StudyStrats
Architecture

Being part of TUMJA was a great chance to work in interdisciplinary teams, connecting ideas across different fields and having an impact on society.

Youssef **Walha**
Digital Enlightenment
Munich School of Engineering

I faced challenges, lived moments of joy and deception, understood the true meaning of compromise and open-mindedness and above all met amazing people.

Yushu **Yang**
Digital Enlightenment
Electrical and Computer Engineering

It was a very precious experience to work with students from different fields in our team Digital Enlightenment at TUMJA!

List of Tutors

Maximilian **Bauer**

MUCtrail
TUM School of Medicine

Supporting the team on their interdisciplinary endeavor and thereby getting many new insights and perspectives as a tutor was a very fruitful experience.

Dominik **Irber**

Africast
Physics

Being a tutor provides great insight into group dynamics and teamwork from a slightly external perspective, while helping the group by sharing experience.

Sebastian **Kaltenbach**

Quintessence
Electrical and
Computer Engineering

TUMJA offers its members an unique combination of science, teamwork and personal growth. It provides countless opportunities to consider obstacles as challenges.

Matthias **Lehner**

Africast
TUM EDU

As a tutor, I support the scholarship holders of TUMJA to develop their projects. Therefore I share my experience with our motivated students.

Konstantin **Riedl**

EvaluaTUM
Mecanical Engineering

For me the TUMJA is a place where science meets society and both influence each other in a positive way.

Sarah **Braun**

Freesearch
Mathematics

The most valuable thing of TUMJA is that it encourages talented people from different backgrounds to let their thoughts fly, be curious and try something unusual.

Panagiotis **Christou**

Freesearch
Electrical and
Computer Engineering

The best reward of being a tutor at TUMJA is knowing that you helped the new generation realize its dreams! Thank you TUMJA.

Danilo **Hackner**

Digital Enlightenment
TUM School of Medicine

TUMJA offers the perfect combination – interesting people, new insights and in the end a project that makes a difference.

Andreas **Heimfarth**

Digital Enlightenment
TUM School of Management

Working with this team of talented and engaged students was inspiring – and a lot of fun.

Kristina **Schick**

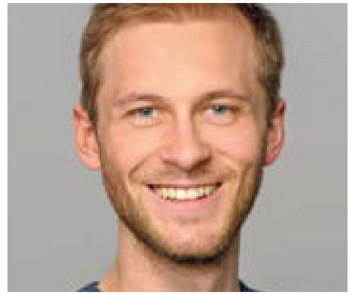
MUCtrail
TUM Medical Education Center

It was a great pleasure to tutor the MUCTrail project group as they worked on the project with a remarkably high motivation, commitment and creativity.

Konrad **Weiß**

StudyStrats
Informatics

As a scholarship holder and tutor, the TUMJA has given me the opportunity for personal growth and meeting the best people to work with in academia.



Martin **Zirngibl**

StudyStrats
Biology, LMU

As a tutor I want to pass on that viable information from my time as a scholarship holder to enable the new generation getting the most out of their time.

List of Supervisors

Prof. Dr. Maria **Bannert**
Digital Enlightenment
TUM School of Education

Cybersecurity is a major issue in our digitized society. Evidence-based promotion of peoples awareness of data security requires smart interdisciplinary research teams.

Prof. Dr. Ernst W. **Mayr**
Africast
Mathematics

I enjoyed the (online or offline or mixed) discussions very much, hopefully the team members did so as well.

Prof. Dr. Annette **Noschka-Roos**
EvaluaTUM
TUM School of Education

Working in an interdisciplinary manner for solving problems, that's one of the reasons why many TUMJA-projects have been always an interesting challenge.

Prof. Dr. Azzurra **Ruggeri**
StudyStrats
TUM School of Education

It's been a real pleasure working with this team – an incredibly creative, smart, curious and motivated group of students! I am very happy how the project turned out.

Prof. Dr. Sonja **Berensmeier**
Freesearch
Mecanical Engineering

A scientific way of approaching problems is a long and intense learning journey, until it comes 'automatically'.

Dr. Veronika **Diem**
Africast
University Library

I'm happy to support the work of TUMJA, in which the participants experience the essential path from the ideas to the outcome.

Prof. Dr. Hans **Förstl**
Quintessence
TUM School of Medicine

It has always been my great pleasure and privilege to teach at the TUM. I would also have loved to study at the TUM – preferably molto vivace!

Prof. Dr. Maximilian **Schiffer**
Digital Enlightenment
TUM School of Management

TUMJA provides a unique opportunity to engage in a transdisciplinary project that incorporates the social responsibility of science.

Dr. Susanne **Witzgall**
Quintessence
Academy of Fine Arts Munich

It was a great joy to support the development of their project and to try to broaden their perspective from my point of view as a humanities scholar.

Prof. Dr. Lisa **Herzog**
Digital Enlightenment (until June 2019)
Faculty of Philosophy, University of Groningen

I saw my commitment at TUMJA as a form of intergenerational solidarity – I've benefitted from various forms of mentoring and would like to pay forward.

Projects 2019

Africast 44
Digital Enlightenment 70
EvaluaTUM 92
Freesearch 116
MUCtrail 138
Quintessence 158
StudyStrats 178

Respekt
Würd
Sachlic
Unterhaltung
Multikulturalismus

Project Report **Africast**

Team	Jaimee Lau Marius Merkle Patrick Sowinski
Tutors	Dominik Irber Matthias Lehner
Supervisors	Dr. Veronika Diem Prof. Dr. (em.) Ernst W. Mayr

Preface by the Supervisors 46
Journalistic part 48
Scientific part 50
Self reflection 64
Posters 66

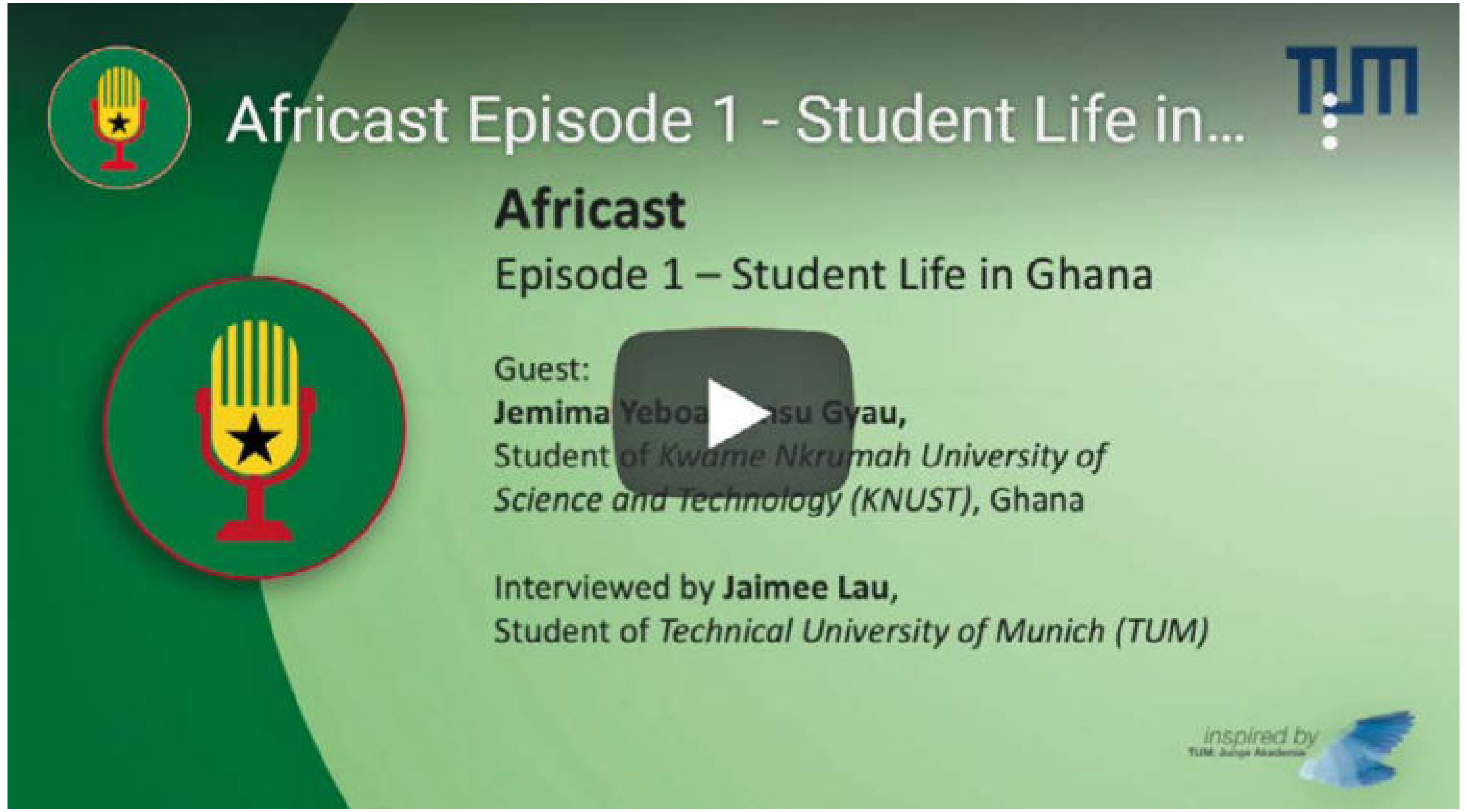
Preface by the Supervisors

Dr. Veronika Diem and Prof. Dr. (em.) Ernst W. Mayr

Africa is said to be the rising continent of this century, it has immense potential, and it is at Europe's southern doorsteps. Africa is also a very important issue on the political agenda in Germany, in relation to many areas, like the economy, migration, or globalization. Hence it appears vey justified that a team – our team – of the TUM: Junge Akademie selected this topic in general and were highly motivated to explore in particular the area of academic and student relationships with Africa. And, to make the whole project more concrete, based on real experiences and not just statistics and surveys, they picked a specific country (Ghana) and a specific university (KNUST, the Kwame Nkrumah University of Science and Technology in Kumasi, the second largest city in Ghana). From its orientation, KNUST has many attributes in common with TUM, and, in terms of numbers, their number of students is even a bit larger.

After collecting a lot of relevant information about Ghana and KNUST, the team established contact with the student community from Ghana at TUM, as well as with a number of TUM faculty with projects and connections in Africa. The most evident outcome and current showpiece of the project is a series of seven podcasts, produced in a really professional manner, and available on YouTube, Spotify, and Soundcloud. These podcasts deal with a number of instructive topics and issues, like student life and cultures in Ghana, various issues of the Ghanaian economy, start-up culture, etc. So far, the distribution of these podcasts has been quite acceptable and encouraging, and it is a pity that, because of the Corona crisis, some supporting events like a workshop scheduled for March had to be cancelled.

In the final phase of the project, it is planned to evaluate the effectiveness of methods like podcasts in the attempt to improve familiarity with social and, especially, academic contexts in different countries considering things like student life and general requirements and outlooks.



Africast Episode 1 - Student Life in...

Africast

Episode 1 – Student Life in Ghana

Guest:

Jemima Yeboa asu Gyau,

Student of *Kwame Nkrumah University of Science and Technology* (KNUST), Ghana

Interviewed by **Jaimee Lau,**

Student of *Technical University of Munich (TUM)*

Africa on the Rise

Countries like Ghana, Kenya, Senegal, Ethiopia or Tanzania are among the fastest growing economies in the world. According to estimates by the German Federal Ministry for Economic Cooperation and Development (2020), Africa will have the world’s biggest potential labour force by 2035. Strong African education, research, and innovation systems will therefore play a decisive role in global development.

International academic cooperation can be hugely beneficial to all countries involved. The Technical University of Munich (TUM) has recognized this potential and launched the *Africa initiative* in 2018, which aims to establish and promote long-term cooperation with partners from the African continent in the fields of education, research and entrepreneurship. There are already around 140 projects and exchange agreements between TUM and institutions in 20 African countries. One area of focus is Ghana, where TUM has built up a partnership with the Kwame Nkrumah University of Science and Technology (KNUST) located in the city of Kumasi. Furthermore, a team of TUM experts together with several partners in Africa has developed the off-road capable electric utility vehicle “aCar,” intended to make people in isolated rural regions of Africa mobile and provide them with better access to healthcare, educational institutions and business activities. Another related project is the “ADLAND” consortium, led by the Chair of Land Management. They work on responsible and intelligent land management concepts and their practical application. The mission includes reducing the unequal distribution of agricultural land in Africa and promoting a more effective use of African soil (Technical University of Munich 2020).

TUM researchers and students in the project “FOG Net” are working on obtaining water from unconventional resources such as dew and fog. In areas with little rainfall, this can represent a feasible addition or even an alternative to using groundwater supplies (idem). Along with this, in 2018, TUM alumni decided to start the non-profit organization *TU eMpower Africa e.V.* This accredited university group of TUM is driven by students, researchers, alumni and friends of TUM and examines how energy transition can foster sustainable development of communities in Africa. The mission is to improve the supply of electricity, drinking water and food in rural communities in sub-Saharan Africa through interdisciplinary research-based solutions. The energy-water-food system built in St. Rupert Mayer, Zimbabwe, is the first of its kind. Solar-powered water pumps extract drinking water and support irrigation, making year-round farming and higher yields possible. The resulting increase in agricultural productivity provides more organic waste, which is recycled in biogas plants.

The long-term vision is to scale up the technological innovations to become economically sustainable, so that profits from food sales help return the initial investment for the solar-powered infrastructure. The sustainability of the projects is ensured through the involvement of local communities, providing them with professional training and therefore ensuring the support for the operation at the technical and social level. With the first pilot project in Zimbabwe, the initiated agribusiness has provided full-time jobs for a farm manager, an accountant, and four farmworkers. *TU eMpower Africa e.V.* aspires to initiate further projects with local stakeholders, including African universities, and to spread the word on scientific conferences to create a global network.

Even though TUM’s *Africa initiative*, the NGO *TU eMpower Africa e.V.* and also the *Ghana Students Union-Munich*, supporting students from Ghana with their studies and careers in Munich, represent a huge potential for the young academic generation of TUM, only few students seem to be informed about it. Successful research partnerships between Europe and Africa depend on individuals and organizations with sufficient information about each other's countries.

While the idea for international collaboration often comes through media such as films, music, written articles or documentaries, the long-term success of such projects depends on a mutual understanding of each other's circumstances, challenges and motivations. Ghana, like most of Africa's nations, suffers from the fact that it is hardly represented in popular media and science in Europe.

We, as team Africast, identified the lack of information about the academic cooperation between TUM and the African continent as a major challenge for the success of the partnership. This is why we have made it our mission to raise awareness and interest for the academic opportunities in Africa, focusing in particular on Ghana. With the realization of an online podcast series, we aim to inform the public about ongoing projects and initiatives in this context. Expertise, a sense of humor and spontaneity are our guidelines for the cross-cultural interviews.

After a general overview of Ghana and the life of young academics at KNUST in the first two episodes, we address more specific topics in the subsequent episodes, including electronic waste or land management in African countries. We see ourselves as neutral reporters who link general information with first-hand experience reports and make them accessible to a broad public. One may be tempted to talk mainly about cultural differences, but our claim is to highlight interesting, perhaps unexpected, similarities between Africa and Europe.

Each of the interviews lasts about 20 minutes and for reasons of authenticity we have refrained from editing the audio files in any form. In this modern and fast-paced world, we consider 20 minutes as the perfect time frame for spreading a message without overloading the listeners with too much information.

In order to achieve the best possible quality, we conducted the interviews in a professional dubbing studio with the support of a sound engineer. In total, we organized three studio sessions and produced seven podcast episodes. Starting in June 2019, we published a new podcast episode once a month. The podcast series is available free of charge on the online platforms YouTube, Spotify, Soundcloud and iTunes.

Since we consider students of TUM as the most interesting subgroup of our audience to understand the overall impact of our project and to draw final conclusions, we decided to organize a multinational workshop with TUM students from Germany and Ghana in March 2020. Unfortunately, we had to cancel the networking workshop because of the COVID-19 pandemic. Due to the external circumstances we decided to conduct the workshop in August 2020 as an online workshop with a smaller group of participants, who listened to one podcast episode and filled out an evaluative questionnaire. The online workshop featured a talk from the TUM Seed Center, providing higher education at the intersection of sustainable energies and entrepreneurship and offering doctoral scholarships for African students. Furthermore, the NGO *TU eMpower Africa e.V.* and the *Ghana Students Union-Munich* presented their work.

We received a total of 27 filled-out questionnaires, eight of them from individuals from Ghana. The survey results serve as a basis for the qualitative research project, which is presented in the following.

Africast

Table of contents:

Abstract

1. Background
    a. Relevance of Ghana in a Global Context
    b. The Kwame Nkrumah University of Science and Technology
    c. What is Interest and how can it be measured?
    d. Podcast as a Form Communication

2. Goals and Methods
    a. Description of the Research Design
    b. Sample and Data Collection
    c. Data Analysis
    d. Variables

3. Outcome and Discussion
    a. Analysis of YouTube Metrics
    b. Analysis of Survey Statistics

4. Summary and Future Goals
    a. Summary
    b. Limitations and Future Goals

References

Abstract

We, team Africast, have set ourselves the goal to raise awareness for and interest in the academic cooperation between the Technical University of Munich (TUM) and the African continent, focusing in particular on Ghana. With the realization of an online podcast series, we aim to inform the public about ongoing projects and initiatives in this context.

To evaluate the impact of our project and to improve our podcast series, we conducted a scientific survey guided by the following research question: “To what extent does the podcast series Africast enhance knowledge and interest with respect to the scientific cooperation between TUM and the African continent among students at TUM?”

In this research, we distinguish between three indicators, namely *active* and *passive interest* as well as *factual knowledge* in order to measure an individual’s awareness of a topic. Based on qualitative and quantitative research methods, we conclude that the online podcast series "Africast" is an effective format to promote interest and knowledge about the scientific partnership between TUM and African countries.

1. Background

a. Relevance of Ghana in a Global Context

Ghana was the first country in sub-saharan Africa to become independent from colonial rule in 1957. The country has experienced no civil wars since its independence and its current democratic political system has been stable since 1993 with peaceful transitions of power between political parties. This stability has allowed Ghana to grow its GDP more reliably compared to neighboring countries in western Africa. The growth rate has been consistently positive since 1983. In 2011, Ghana became the fastest growing economy in the world for the first time, mostly caused by the start of oil production in late 2010 (Standard Bank 2011). Before its independence, Ghana was known as the colony of the “Gold Coast.” This is still reflected today with gold being Ghana’s largest export by trade value, followed by oil and cocoa (Observatory of Economic Complexity 2018).

What sets Ghana apart from many other nations is how they spend their budget. Education accounts for 20 to 30 percent of government spending, which is reflected in a rapidly increasing number of students in secondary and tertiary institutions (Trading Economics 2020a, Trading Economics 2020b). The Ghanaian leadership is aiming to diversify its economy and prepare for sustainable growth in the coming decades, building on the foundation of a well-educated workforce.

The two largest public universities in Ghana are the University of Ghana in the capital Accra and the Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi (University of Ghana 2018). Apart from students enrolled on-campus, Ghanaian universities also offer extensive programs for part-time studies and remote studies, allowing even more people to pursue a degree who might otherwise be hindered by financial difficulties (Siabi-Mensah, Badu-Nyarko and Torto 2009). The term “sandwich students” is commonly used for those that pursue a job outside of university during the regular academic semester and then participate in courses at the university during the semester break. Students from Ghana are also increasingly visiting universities abroad (Trading Economics 2020c).

Ghana’s universities have a stronger focus on education than on research compared to their European counterparts. Nevertheless, the number of research facilities is increasing. Research institutes in Ghana are still hindered by a lack of funds. They are at risk of being stuck in a feedback loop, where low funding leads to fewer internationally visible publications, which in turn leads to less funding (Alabi and Mohammed 2018). This loop can be broken by cooperating with internationally recognized universities like TUM. Reciprocally, TUM benefits from working with researchers in Ghana, because they gain access to environments that are only available there. The aCar project, for instance, which led to the development of a low-cost electric vehicle for rural areas, was able to verify and improve their product design in Ghana’s rural environment with feedback from the local population.

b. The Kwame Nkrumah University of Science and Technology

The Kwame Nkrumah University of Science and Technology (KNUST) was founded as the Kumasi College of Technology in 1952 and gained university status in 1961. The main campus is situated close to the city of Kumasi, which has over 3 million inhabitants and is the current capital of the Ashanti Region in Ghana, as well as the traditional capital of the Asante Kingdom (World Population Review 2020). The kingdom, led by a king called the Asantehene, has existed since 1670 and the royal lineage continues to this day (Shillington 1995). The current Asantehene, Osei Tutu II, started his reign in 1999 and is also the current chancellor of KNUST.

Unlike the coastal territories of modern-day Ghana, which were formerly the British colony of the Gold Coast, the further inland situated area of the Asante Kingdom strongly opposed British influence and maintained varying degrees of self-rule throughout the colonial era. In 1957, the modern nation of Ghana was formed by combining the territories of the Gold Coast colony, the Asante Kingdom, British Togoland, and some more territories to the north (Shillington 1995).

The foundation of KNUST is also tied to the royal family of the Asante Kingdom. Asantehene Prempeh I strived to modernize the kingdom and envisioned a university in Kumasi. His younger brother succeeded him in 1935 as Asantehene Prempeh II and oversaw the establishment of the Kumasi College of Technology, which later became KNUST (Akyeampong 1999). Initially, the college consisted of the School of Engineering and the Department of Commerce. Over time, more schools and departments were established, for instance the faculties of pharmacy, agriculture, and architecture. As the college grew, the focus shifted increasingly towards science and technology, with the result that some departments, including the department of commerce, were separated and handed over to other institutions (KNUST 2020b).

Shortly after Ghana's independence in 1957, the government decided to establish a public and independent university system in Ghana, which led to the foundation of two universities in 1961: The University of Ghana based on the University College of the Gold Coast in Legon, Accra, and KNUST in Kumasi. Today, these two universities are the largest universities in Ghana, each having over 30,000 students (KNUST 2020b).

KNUST was named after Kwame Nkrumah, the first prime minister and president of Ghana. Nkrumah envisioned a strong national education system in Ghana. However, after he transformed the country to a one-party state in 1964, and was overthrown in a revolution in 1966, the university was renamed, not including his name anymore. Kwame Nkrumah was added to the university's name again in 1998.

Today, KNUST is ranked as the best university in West Africa and 14th best in all of Africa, according to the US News Best Global Universities ranking (US News 2019). UN Secretary General and Nobel Peace Prize laureate Kofi Annan, who visited TUM in 2018, is also an alumnus of KNUST. Since 2005, KNUST follows a collegiate model, where the different colleges within the university operate mostly autonomously. There are currently six colleges:

- College of Agriculture and Natural Resources
- College of Health Sciences
- College of Humanities and Social Sciences
- College of Art and Built Environment
- College of Engineering
- College of Science

There is also a dedicated Institute of Distance Learning for those who seek a degree while working full-time (KNUST 2020a).

The campus has six halls of residence for its students. Additionally, there are private hostels around the campus for non-resident students. Other facilities on the campus include: an art gallery, two churches, a mosque, botanic gardens, and a swimming pool (KNUST 2020c).

c. What is Interest and how can it be measured?

In relation to our research question, we have identified knowledge as well as interest as two areas of particular importance for our analysis, and defined knowledge and interest as the most relevant dependent variables.

In the literature, knowledge and interest as well as their interconnection have been subject to a wide range of interpretations (Habermas 2015). In order to evaluate whether we could enhance either one or both variables, the two concepts must be defined and differentiated from each other. More specifically, an attempt is made to formalize what we call *passive interest* and *active interest* as two different dimensions of interest. In a second step, knowledge and its interconnection to interest will be discussed.

Guilford et al. (1954) have defined interest as a "general behaviour tendency an individual has to be attracted to a certain class of incentives or activities." This definition is interesting in the sense that it differentiates between two types of attractions. The former, a mere attraction to incentives, is considered as *passive interest* in our analysis. Important cases of such incentives include a need for information, desire for knowledge and in general further engagement with the topic. In contrast, we classify an attraction to activities as active interest, where behaviour patterns have a proactive nature in common. Usual patterns of *active interest* may appear in the form of a commitment to active participation, seeking out for opportunities and, more generally, making original contributions towards a certain topic.

Another analogy for active and *passive interest* in the literature can be found as the "exchange theory of interest groups" (Salisbury 1969). The authors distinguish between an entrepreneur/organizer (practicing active interest) and a customer/member (practicing *passive interest*). They claim that both interest groups are necessary in a sense that members perceive benefits offered by leaders who in turn get rewarded. In fact, a sufficient number of both interest groups are indispensable for a group to survive, ensuring a balanced exchange.

With respect to knowledge, we solely focus on propositional/descriptive knowledge, i.e. awareness of facts that can be expressed in words (rather than procedural knowledge exercised in the performance of some task). In the context of a podcast episode, enhanced knowledge can be measured in memorising quantitative or qualitative information presented in the interview. At first sight, interest and knowledge seem to be two decoupled domains that could be analyzed separately. Yet, there are studies which have measured significant correlations in a participant's interest (either of active or passive nature) and knowledge towards a certain topic. As an example, Garner et al. (1991) studied the interdependencies between prior knowledge (before reading the article, referred to as topic knowledge), interest and posterior knowledge (after reading the article, referred to as text recall). Garner et al. (1991) noted that among the participants comprising a group of adults, these three variables were highly associated. More specifically, they observed that increased prior knowledge generally implied more intense interest in the topic.

Initially, we followed an equivalent procedure in the sense that we wanted to evaluate the participant's knowledge a priori, a posteriori and analyze their interest. As we had to shift our workshop in-person format to an online format, we had to adapt our interview approach and could not analyze the participant's prior knowledge. Nevertheless, we were interested in isolating the three variables (active interest, *passive interest* and knowledge) in order to analyze the impact of the podcast series and possible interdependencies or correlations between the variables.

d. Podcast as a Form of Communication

More than a decade ago, various studies have classified podcasts as a possibly revolutionary form of communication. In 2004, the word "podcast" was declared word of the year by the New Oxford American Dictionary. The authors argue that the podcast hype in the 2000s was primarily caused by a rise of portable digital audio players including the iPod nano and iPod Touch. Even though the technical capabilities of such devices were very limited in terms of memory capacity and storage, they were the first portable devices with internet connection and, hence, provided a revolutionary new way of listening to simple audio files. Despite significant advances in technology, the authors already recognized reasons for the potential success of podcasts ¬– their nature of allowing individuals to listen to "what they want, when they want, where they want, and how they want" is perfectly suited to students (Jham 2007, Soc 2006).

In the past years, technological breakthroughs including the invention of the smartphone, worldwide internet connection (3G, 4G, LTE) and large internet streaming platforms, including Spotify, YouTube and Soundcloud, have laid the foundation for the rise of podcasts as a media format. A recent study of AS&S Radio and Facit Research in 2018 has performed a quantitative study with more than 3000 people. They classified a person as a podcast consumer if he/she has listened to at least one podcast in the past twelve months. Based on this definition, they found that 29% of all questioned individuals are podcast consumers. As predicted by the two studies mentioned earlier, primary target groups are indeed young adults. Out of the 29%, 40% were between 30 and 49 years old and 31% between 14 and 29. Finally, according to AS&S Radio, people who consume podcasts on a regular basis have often received higher education and share a deeper passion for technology than people who don't consume podcasts (Domenichini 2018). Given that our primary target group, students from TUM, is largely concentrated in the age group of 18 to 30 years, is at an advanced stage of education and with shared interests in technology, conveying information in the form of podcasts seems to be a reasonable choice.

Moreover, the study explains that given the diverse audience of podcast listeners, their ways of listening to podcasts differ significantly. Just to name two differences, regular podcast listeners use both conventional websites as well as mobile apps, 25% are willing to pay for streaming services while the majority prefers to enjoy free podcasts. To match such trends, we have published our podcast series on Spotify (app, paid), Soundcloud (app/website, free), YouTube (app/website, free). Finally, according to AS&S, the topics regular podcast consumers listen to are diverse. The most prominent include society and culture (21%), education (20%) as well as science (17%). With the podcast series Africast, the attempt was made to cover all of these areas by inclduing a broad range of topics.

There are many successful examples of scientific podcasts. The University of Maryland School of Medicine (USA), for instance, produced a podcast sharing information about topics relevant to medical studies, which has achieved 20.000 downloads within a short period of time as well as very positive feedback by the students (Frayha 2019).

The online podcast series Africast, which informs TUM students about the scientific cooperation between TUM and the African continent, is based on the assumption that a podcast is a suitable communication format for the target group of students. A comprehensive analysis of the feedback and the evaluation of how our listeners perceived the podcast format is given below.

2. Goals and Methods

a. Description of the Research Design

The online podcast series Africast was created in order to enhance knowledge and interest with respect to the academic cooperation between TUM and the African continent among students at TUM. Accordingly, the online podcast series is a significant element of our research design, which is supported by an online survey. In order to determine to what extent the podcast series Africast increases knowledge of and interest in the cooperation between

TUM and the African continent, we analyzed the podcast statistics as well as the survey statistics. The research outcomes are presented in the following.

The first two episodes of the Africast podcast series were recorded in May 2019. In July 2019 the third and fourth episode followed and in August 2019 we recorded three more episodes. In advance, meetings with the podcast guests took place to discuss a rough guideline for the questions and answers. It is important to note that at no time did we use a given scripted text. This was important to us, so that the dialogues could develop spontaneously and the speakers act naturally. To ensure the best possible quality, the interviews were conducted in a professional dubbing studio with the support of a sound engineer.

Each episode lasts around twenty minutes. We consider this as an appropriate time frame for conveying a message without overloading the listeners with too much information. For reasons of transparency the recordings were not edited or modified afterwards. We start each episode with a short introduction of one minute in order to give the podcast series a standard format and sense of continuity. This intro explains who we are and what the project Africast is all about. To increase the information value of the podcast series, we decided to implement several “infoboxes” that provide additional information on the screen while listening to the episode.

To offer the audience a brief introduction about Ghana, the first two episodes cover general information about the culture, the history and the geography of Ghana. Some of the topics discussed are the influence of the colonial past, the independence of Ghana, the national languages, the tradition of national service, the university system or possible career perspectives.

A total of seven podcast episodes were published by the end of 2019. After the thematic introduction in the first two episodes, the subsequent podcast episodes focus increasingly on concrete projects and cover not only Ghana but also other African countries. The specific topics of episodes 3 to 7 include, for example, electric mobility, land and waste management, economic growth and startups.

b. Sample and Data Collection

In order to evaluate the effect of the podcast series Africast, we conducted a survey. In August 2020, we held an online workshop via Zoom, where the participants were asked to listen to the podcast episode 6 “Land Management in Africa” with Prof. Dr. Walter de Vries, TUM professor for land management at the Department of Aerospace and Geodesy. After this twenty-minute audio part, the participants were asked to fill out the online survey.

We decided to create two different questionnaires, one explicitly for students from Ghana and one for all other participants. This allowed us to ask more specific questions per target group. The two questionnaires were similar in structure and differed only in a few specific questions. The questionnaire for students from Ghana included 30 questions, three of which were open questions. The questionnaire for the other workshop participants featured 31 questions with only a single question that was not standardized.

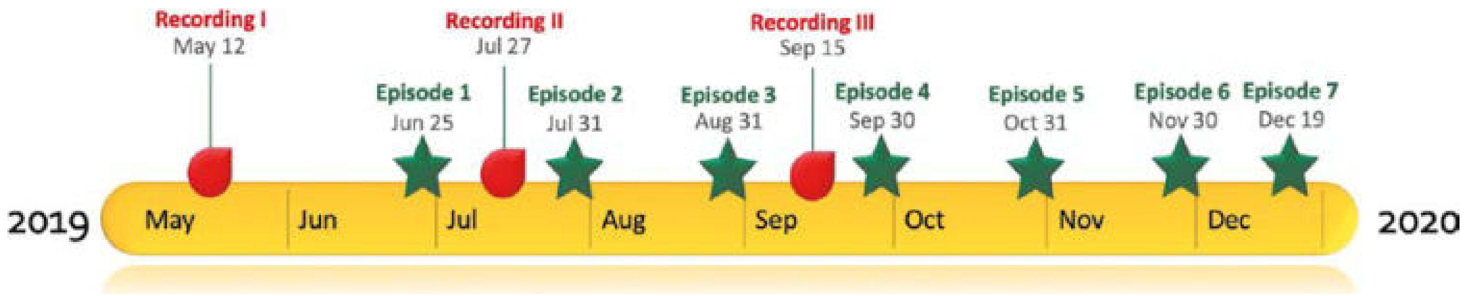


Figure 2.1.1: Release schedule of the Africast series

In total, we received twenty-seven filled-out questionnaires, eight of them from individuals from Ghana. Around 63% of all respondents are or were enrolled at TUM. With regard to the age distribution, there was a relatively large difference between the two questionnaires: Out of the participants who did not come from Ghana, almost 68% were under 24, while 75% of the participants from Ghana were 30 or older. This confirms our experience that many students from Ghana tend to be older. This may be due to the fact that Ghanaian students who graduate from accredited tertiary institutions are required under law to do national service for one year.

The two distinct surveys served as a basis for the qualitative analysis guided by our research question and the literature review.

c. Data Analysis

Our research is not about achieving statistical significance in order to draw conclusions about a larger population. We decided to answer the research question by working with a rather small sample size. Since the research question is very specific, we preferred the option of possibly obtaining very specific and detailed research results rather than results that can be generalized. Consequently, we refrained from applying statistical models, but evaluated the numerical data from Youtube as well as the survey in absolute terms. This method allowed us to quantify the research variables and uncover interesting patterns. In addition, we included a few open questions in the survey. With this method, we hoped to obtain individual input from the respondents. In fact, the open questions resulted in unexpected and very interesting information that would not have been revealed in closed questions with standard answers.

d. Variables

All in all, Ghana is an African country with a well-established educational system in primary and secondary education as well as in the tertiary sector. Although the number of research departments in Ghana is increasing, there is still a lack of funding and of international collaborations. One reason for that might be that not enough European researchers perceive researchers from Ghana as promising partners. An explanation for this could be that their general knowledge of and interest in Ghana and the African continent is rather low, perhaps due to a lack of information.

As podcasts turned out to be an acceptable format for disseminating information, we asked students at TUM, the researchers of the future, if podcasts increase their knowledge and interest with respect to the scientific partnership between TUM and the African continent, in particular Ghana and the KNUST. To answer the research question, we differentiated between three dependent variables that are influenced as a result of the podcast: a) *passive interest*, b) *active interest* and c) Factual knowledge.

3. Outcome and Discussion

a. Analysis of YouTube Metrics

Africast is available on multiple different platforms, namely on YouTube, Soundcloud, Spotify and iTunes. However, YouTube stands out as the main platform for the podcast series. It is the only one where the podcasts are available in video format, not just in audio, with additional, visual information in the form of “infoboxes.” We looked at the analytics data on YouTube to see how our episodes perform.

Table 3.1.1 shows a general overview of each episode’s performance based on four metrics:

- Views: number of views (not unique, could be multiple from same person)
- Average view duration: watchtime per view (indication of how engaging a video is)
- Impressions: number of shown impressions (search results, suggestions, browsing, etc.)
- Click-through rate: percentage of impressions that were clicked on

These statistics range from June 22, 2019 to August 23, 2020. This means that older episodes have an advantage, since they have been available for a longer period. This advantage is somewhat mitigated, since this analysis takes place over half a year after the last episode was published. The oldest episode has statistics spanning over fourteen months and the youngest over seven months. As we will see later, all but one episode have reached a stagnation point by this time, so their metrics are not significantly changing anymore.

The number of views is strongly influenced by the extent to which we have promoted a video, sharing it with friends and colleagues and distributing the link via social media. Episodes 1 and 4 have been advertised the most, which correlates with them being the most viewed ones. To see which videos perform well independently of advertising, we also compare how the view counts of episodes developed over time. We use episode 2 ("Cultures of Ghana"), which did not perform extraordinarily in any metric, as a benchmark. Figure 3.1.1 compares it to the less viewed episodes: 3, 6, and 7. Figure 3.1.2 compares it to the more viewed episodes: 1, 4, and 5.

Episode	Views	Avg View Duration (min)	Impressions	Click-Through Rate
1	386	2:18	1161	3.5%
2	100	3:13	692	3.8%
3	113	2:42	720	5.1%
4	348	3:44	1048	3.3%
5	234	3:30	1555	6.5%
6	110	4:10	861	4.0%
7	116	3:12	268	7.8%

Table 3.1.1: General overview of episode metrics

Episodes 2, 3, 6, and 7

As can be seen in Figure 3.1.1, the episodes 2, 3, 6 and 7 all have similar view counts over time. They are the four episodes of the series with the lowest view counts at the time of analysis, each being slightly above 100 views. Each episode shows the same trend. The number of views grows quickly right after publication. This growth slows down quickly within the first few days and stagnates. It appears that the episodes only gain views due to initial advertising by the publishers, e.g. on social media, and fail to attract new viewers without it. Nonetheless, episode 6 ("Land Management") has the highest average view duration with over four minutes, which indicates it might be more engaging than other episodes. It also has a second growth phase in August 2020, which is caused by our research survey requiring participants to watch episode 6 before filling out the questionnaire.

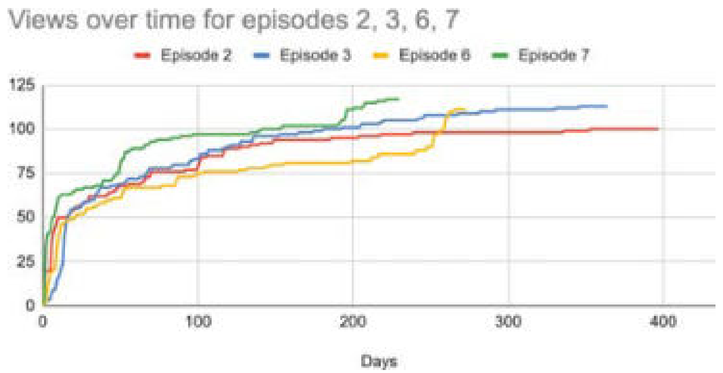


Figure 3.1.1: View counts of episodes 2, 3, 6, and 7 over time

Episode 7 ("Economy & Startups") is slightly unusual, because it has two distinct growth spurts after its initial stagnation, the latest one being over 190 days after the episode was published. It also has the highest click-through rate at 7.8%. It is possible that this episode has more potential to grow. However, these growth phases could also be caused by the fact that the newest episode is linked on top of the Africast project webpage, which means it could gain new viewers whenever the Africast project was promoted in general.

Episode 1

For obvious reasons, the first episode ("Student Life") can be considered as an outlier. It has the highest view count, which is probably due to the fact that it is the first Africast episode most people watch. However, it also has the lowest average view duration, which might be due to the same reason. Uninterested new viewers will only listen to the podcast for a short time. Figure 3.1.2 shows that its view count grew very quickly at the beginning as result of intensive advertising. A link to the episode was even shared with an audience of over 100 students during an information event, which led to a lot of views, but probably only few meaningful interactions. This might have further reduced the average view duration of the episode. Episode 1 has seen additional growth during the next months while other episodes were being published. Nonetheless, after the podcast series stopped being advertised regularly on social media in 2020, the growth stagnated.

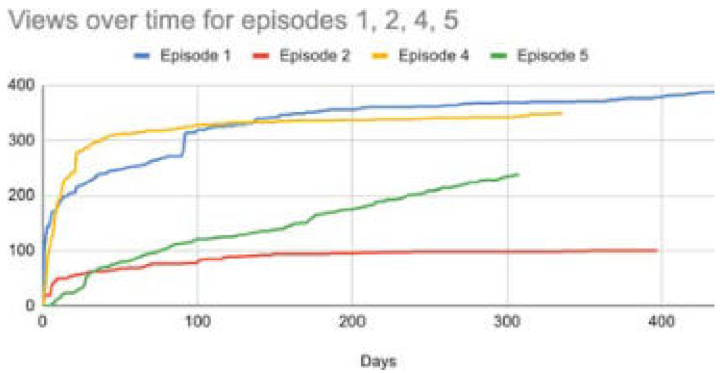


Figure 3.1.2: View counts of episodes 1, 2, 4, and 5 over time

Episodes 4 and 5

Apart from the first episode, episode 4 ("Renewable energy systems") and episode 5 ("Infrastructure & Mobility") stand out with a high number of views. They both appear to be more engaging than the other episodes with an average view duration of roughly three and a half minutes. However, their view counts are growing in very different ways.

Episode 4 experienced quick growth in the beginning due to promotional efforts. This initial growth spurt lasted for over two weeks, which is longer than the other episodes. This correlates with our observation that episode 4 generated more interest on social media and was shared by more people, likely due to the fact that renewable energy was a widely discussed topic at that time, potentially influenced by the "Fridays for Future" movement in 2019. However, after the initial successful phase, the episode also stagnated.

Episode 5 stands out when comparing the view counts over time. As can be seen in Figure 3.1.2, it is the only episode that does not stagnate, but keeps growing linearly. This result is quite surprising, since the episode did not appear to be very successful at first. What sets this episode apart is that it is favoured by the YouTube algorithm for reasons unknown to us. It has the highest number of generated impressions and a high click-through rate of 6.5%.

There are five sources of impressions on YouTube:

1. Results in the YouTube search
2. Suggestions after another video and on the sidebar
3. Browse features on the home page
   (Subscriptions, Trending, etc.)
4. Thumbnails on a channel page
5. Thumbnails in playlists

Search, suggestions and browsing, are arguably the more powerful ones for reaching new audiences, since the channel page and playlists already require some interaction with the video creator or series.

The uniqueness of episode 5 is most clearly seen when comparing the traffic sources of the different episodes. Figure 3.1.3 shows the traffic sources for episode 4. External sources, which come from advertising on social media and other platforms, are by far the biggest factor. For all other episodes, apart from episode 5, external sources are the largest contributor as well. However, as seen in Figure 3.1.4, episode 5 has the YouTube search as its biggest traffic source instead.

Episode 5's success in YouTube's search algorithm leads to an increased view count, but it also relates to one of the lowest average view durations at 2 minutes and 23 seconds compared to other traffic sources, as can be seen in Figure 3.1.4. For instance, viewers coming directly from the video link had a much higher average of six minutes seventeen seconds. The other two kinds of "strong" impressions, browse features and suggestions also had higher average view durations, with suggestions having the highest average at seven minutes sixteen seconds.

This observation can also be made when looking at the data for all seven episodes, where suggestions result in one of the highest average view durations at five minutes two seconds, significantly above the total average of three minutes thirteen seconds. However, when looking more closely at the data, we discover that most suggestions are being shown after the viewer watched another episode of Africast, which implies that they already have some interest in the series.

Conclusions from YouTube Metrics

In general, the success of the podcast significantly depends on advertising on social media and other platforms. Nonetheless, the episodes were also able to attract some new viewers independently of our efforts through impressions generated by the YouTube algorithm. In this regard, episode 5 ("Infrastructure & Mobility") stands out in particular, continuously generating new impressions in the YouTube search and thus attracting new viewers even without the publisher's influence.

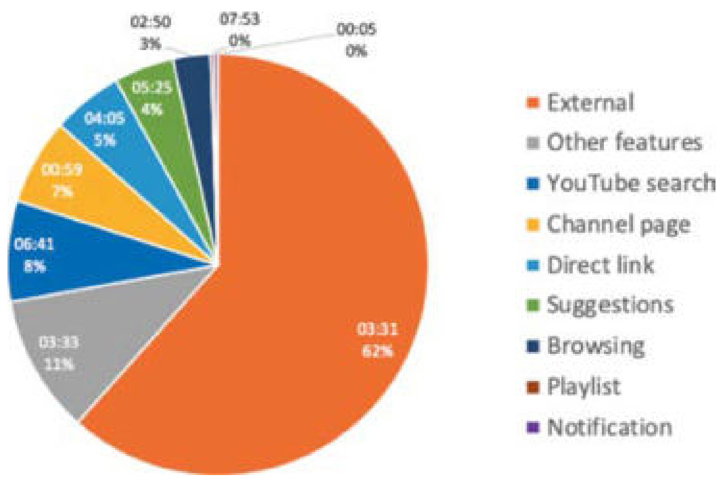


Figure 3.1.3: Traffic sources with average view durations for episode 4

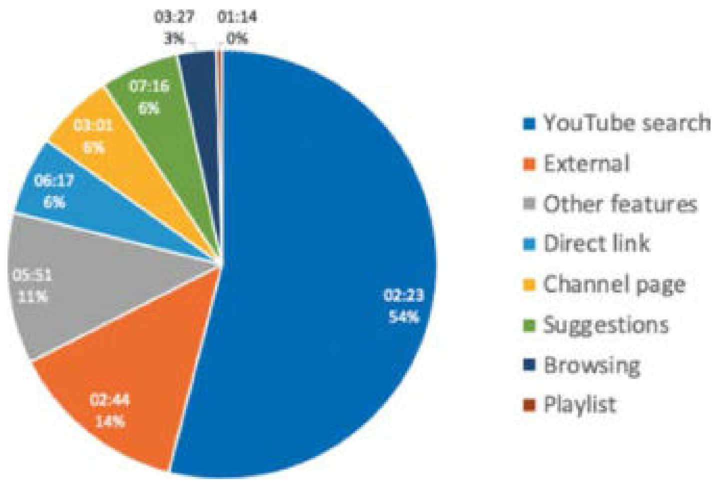


Figure 3.1.4: Traffic sources with average view durations for episode 5

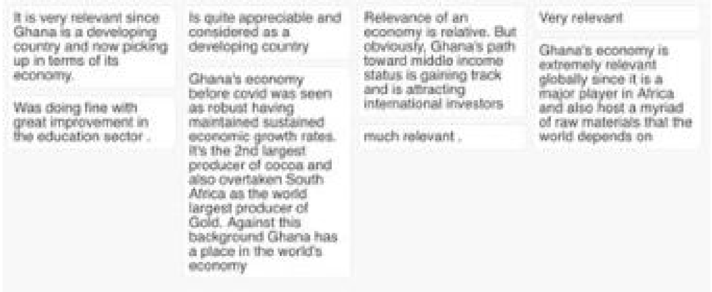
Furthermore, the average view duration for each view can indicate how engaging the content was for its viewers. Given that our episodes are mostly around twenty minutes long, the total average of slightly over three minutes seems quite low and means that most viewers did not watch the episodes in full. Further research should investigate how the viewer's attention can be maintained for longer or whether the podcast format should be shortened.

b. Analysis of Survey Statistics

Survey for Students from Ghana (8 participants)

Relevance of Ghana
Half of the respondents (50%), who have their origin in Ghana, think that German students have too little knowledge about Ghana.

To learn more about the relevance of Ghana, we asked the respondents how relevant Ghana's economy is today in a global context. A few answers are presented in the following:



It is very relevant since Ghana is a developing country and now picking up in terms of its economy.

Was doing fine with great improvement in the education sector .

Is quite appreciable and considered as a developing country

Ghana's economy before covid was seen as robust having maintained sustained economic growth rates. It's the 2nd largest producer of cocoa and also overtaken South Africa as the world largest producer of Gold. Against this background Ghana has a place in the world's economy

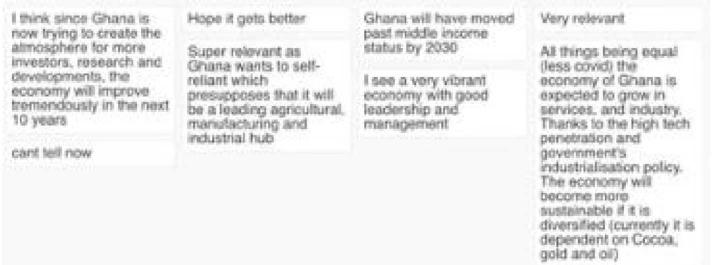
Relevance of an economy is relative. But obviously, Ghana's path toward middle income status is gaining track and is attracting international investors

much relevant .

Very relevant

Ghana's economy is extremely relevant globally since it is a major player in Africa and also host a myriad of raw materials that the world depends on

Next, the participants were asked what the global relevance of Ghana's economy will be like in 10 years. Some answers can be read here:



I think since Ghana is now trying to create the atmosphere for more investors, research and developments, the economy will improve tremendously in the next 10 years

cant tell now

Hope it gets better

Super relevant as Ghana wants to self-reliant which presupposes that it will be a leading agricultural, manufacturing and industrial hub

Ghana will have moved past middle income status by 2030

I see a very vibrant economy with good leadership and management

Very relevant

All things being equal (less covid) the economy of Ghana is expected to grow in services, and industry. Thanks to the high tech penetration and government's industrialisation policy. The economy will become more sustainable if it is diversified (currently it is dependent on Cocoa, gold and oil)

Podcast
Half of the respondents from Ghana (50%) listen to podcasts a few times a month.

It is important to note that 63% of the respondents from Ghana are not sure if the Africast podcast series is an adequate instrument to inform students about Ghana. However, all participants of this survey (100%) feel that the Africast podcast series should be heard by more people.

- 50% say that most of the information of the podcast episode was not new to them. We can conclude that the students from Ghana were familiar with more information than the other TUM students, yet they were also able to learn new things.
- 50% of the respondents from Ghana think there could have been more interesting topics for the podcast episodes. This is an interesting finding. In retrospect, our podcast topics were perhaps too general to successfully address students from Ghana.
- 88% of the survey participants think that the speaking parts of the interviewer and the guest should be more balanced. Interestingly, the students from Ghana seem to have a completely different opinion than the other TUM students (90% think that the speaking parts of the interviewer and the guest should not be more balanced). It would have been helpful to clarify personally how this great discrepancy came about.

Finally, all participants (100%) would be interested in a podcast episode with more than one guest.

Survey for the other Workshop Participants (19 participants)

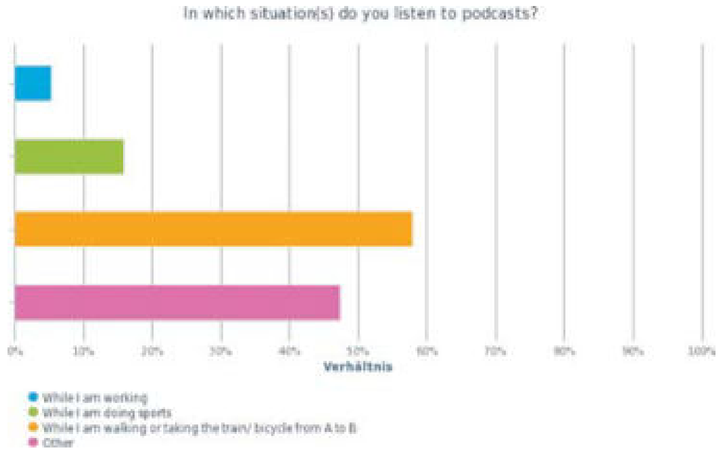
Active Interest
- 79% would like to travel to Ghana or another African country as a tourist.
- 21% could imagine studying at KNUST in Ghana for one semester or for a complete Master's degree/PhD.
- 84% would be interested in doing an internship or work in Ghana or in another African country.
- 47% would be interested in joining a NGO in Ghana or in another African country.

Passive Interest
- 63% are planning to listen to more Africast podcast episodes.
- 37% are going to subscribe to the newsletter of the Africa initiative.
- 53% would like to network with TUM students from Ghana or TUM students/ lecturers who are engaged in a scientific project in Africa.
- 63% are going to talk with friends and family about the Africast podcast.

Factual Knowledge
With one of the three knowledge questions we wanted to find out how many people carefully read the infoboxes while listening to the podcast. The specific information was, hence, not mentioned in the podcast episode, but only displayed in the infobox. 58% answered this single choice question correctly.

With the other two knowledge questions, we asked for information that was mentioned by our guest during the podcast episode. In each case more than 70% knew the correct answer.

Podcast
All participants (100%) think the Africast podcast is an adequate instrument to inform students about Ghana.

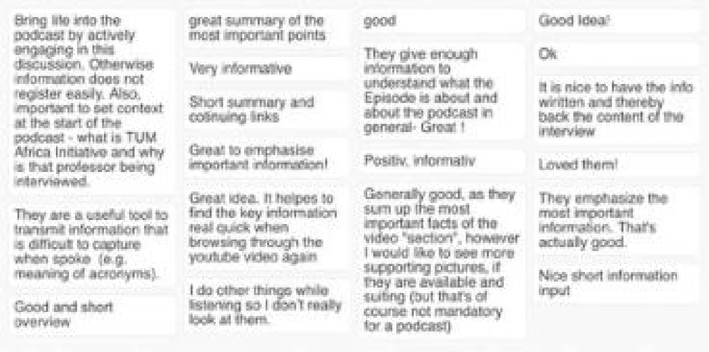


- 95% feel that the Africast podcast series should be heard by more people.
- 84% say that most of the information of the podcast episode was new to them.
- 32% think there could have been more interesting topics for the podcast episodes.

- 90% think that the speaking parts of the interviewer and the guest should not be more balanced.
- 84% would be interested in a podcast episode with more than one guest.
- 47% of respondents listen to podcasts a few times a month.
- 90% think that the Africast podcast episodes with a duration of about 20 minutes are just right, and, hence, not too long or too short.

According to 84%, the information density of the Africast podcast episode is just right, and, hence, not too low or too high.

Based on the question "What do you think of the infoboxes?" we received the following answers. Overall, the feedback regarding the infoboxes is quite positive. The infoboxes seem to be an adequate instrument to highlight important key information.


Bring life into the podcast by actively engaging in this discussion. Otherwise information does not register easily. Also, important to set context at the start of the podcast - what is TUM Africa Initiative and why is that professor being interviewed.

They are a useful tool to transmit information that is difficult to capture when spoke (e.g. meaning of acronyms).

Good and short overview

great summary of the most important points

Very informative

Short summary and cotinuing links

Great to emphasise important information!

Great idea. It helpes to find the key information real quick when browsing through the youtube video again

I do other things while listening so I don't really look at them.

good

They give enough information to understand what the Episode is about and about the podcast in general- Great !

Positiv, informativ

Generally good, as they sum up the most important facts of the video "section", however I would like to see more supporting pictures, if they are available and suiting (but that's of course not mandatory for a podcast)

Good Idea!

Ok

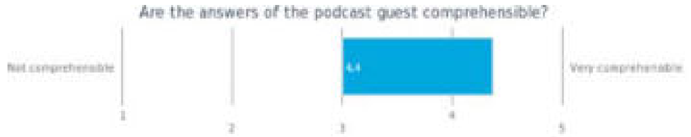
It is nice to have the info written and thereby back the content of the interview

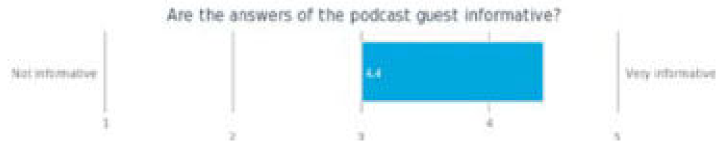
Loved them!

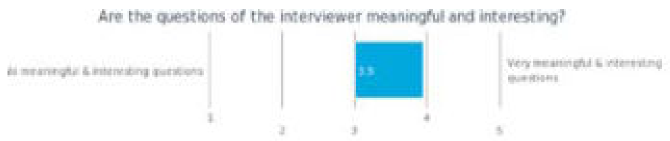
They emphasize the most important information. That's actually good.

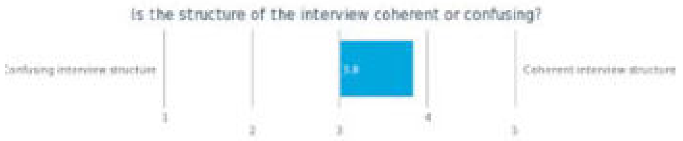
Nice short information input

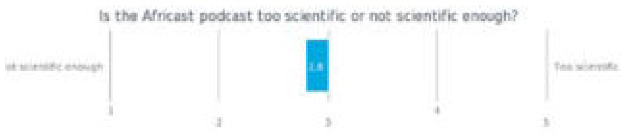
Further evaluation indicators are displayed in the following:











Conclusions from Survey Statistics

The podcast presents information that was known by many of the Ghanaian participants of our survey, but new to most of our other participants, which reflects the mission of Africast: informing TUM students about scientific projects and initiatives in Africa. On both sides, a significant portion stated that there could have been more interesting topics for the podcast; however, we have no details on what would constitute a more interesting topic for these participants.

The Africast podcast format in itself was received positively by both sides, including a significant number of people who have regular experiences with podcasts. While all non-Ghanaian students agreed that Africast is an adequate source of information, most of the Ghanaian students were skeptical. Nonetheless, most of the Ghanaian students agreed that Ghana's relevance is increasing and students in Germany should be more informed about this development. They might be skeptical about the podcast, because it did not highlight information that they consider the most important. This could be improved with a screening process, where experts, in this case people from Ghana, would check the topics of the podcast before publication and give their feedback on what information is crucial and what is redundant.

When looking at the interest of non-Ghanaian students, surprisingly, *active interest* is more prevalent than *passive interest*. A wide majority would like to visit Ghana or another African country as a tourist or for work, but only a minority would like to study there. This correlates with our hypothesis that most Europeans do not view African countries as a destination for scientific work yet. However, we also need to consider that students usually only go abroad to a foreign university once or twice during their academic lifespan, which means they will only have a small selection of top destinations that they pursue. Students might be more open to travel to Africa as a tourist, for internships or other projects, since those trips can be pursued an unlimited number of times and visiting one country does not exclude visiting another one.

Considering *passive interest*, many participants indicate that they would like to contact more people involved with projects in Ghana and would like to keep learning about related topics. There is a potential for related projects and institutions to approach students based on their existing level of interest.

4. Summary and Future Goals

a. Summary

The Ghanaian economy has been on an upward trajectory over the past three decades, yet a number of challenges undermine growth, redistribution and sustainability. Issues such as electronic waste, infrastructure, mobility and energy supply require innovative and efficient solutions to ensure the sustainable and integrative development of this African country. After more than sixty years of independence, the potential for international partnerships working on scientific solutions is more significant today than ever.

In order to successfully attract academic minds from all over the world, they must have a certain level of knowledge and interest. Evaluating the impact of the informative podcast series Africast, we differentiated between the following three variables: *factual knowledge*, *passive interest* and *active interest.*

In summary, Africast proved to be an effective format to promote interest in and knowledge about the scientific partnership between TUM and the African continent. Most of the participants of the survey rated the design and structure of the podcasts positively. In addition, a majority of respondents indicated *passive* as well as *active interest* in engaging with projects, initiatives or individuals from Ghana or another African country. Finally, the knowledge questions were answered correctly by most participants. Consequently, it can be concluded that the information from the podcast and its infoboxes increase the interest and the factual knowledge of the listeners.

The performance of a podcast episode on Youtube depends significantly on advertising on social media and other platforms. Nonetheless, the episodes were also able to attract some new viewers independently of our efforts through impressions generated by the YouTube algorithm.

As the podcast series will continue to be available on various online platforms in the future, Africast will continue to have an informative impact on individuals who listen to the episodes. The episodes can be shared, for example, by organizations and academic institutions as a source of information about specific topics related to Ghana and other African countries.

b. Limitations and Future Goals

The individuals who participated in the survey had to listen to one specific podcast episode before providing their opinion. In the workshop invitation, we shared the link to all podcast episodes. However, we do not know if the persons questioned have listened before to other Africast episodes. This is why we have to assume that the evaluation of the podcast series is only based on the perception of one episode and might therefore be partially biased.

In addition, the online survey was conducted without supervision and the participants were not interviewed on a face-to-face basis. It is important to note that the individuals can easily make false or distorted statements in anonymous surveys. Also, one must assume that questions are sometimes not read carefully. Due to the anonymous online format, the participants had no possibility to give feedback or clarify any questions with respect to the survey.

Since the podcast series has a strong focus on Africa, in particular on Ghana, the team quickly agreed that it would be a great milestone for the project to organize a trip to Ghana. We were highly motivated to experience Ghana's culture first hand and to meet students and professors of KNUST in Kumasi. The idea behind the planned trip was to learn about less popular initiatives in Ghana and get inspiration for new podcast episodes. Unfortunately, we had to cancel the trip, which was planned for April 2020, because of the travel restrictions during the COVID-19 pandemic.

The fact that we ourselves have never been to Ghana is a significant limitation of the project Africast, as we could only report from a bird's eye view about the project and initiatives. We tried to compensate for this problem by meeting delegates of the KNUST in Munich and by building a broad network with TUM students from Ghana.

Another potential limitation of the project Africast is the cancellation of the networking workshop “Africast presents Ghana & Friends,” which was planned for March 15, 2020. The German government and TUM enforced rigorous hygiene regulations in consideration of the coronavirus. In addition, we felt personally uncomfortable with the risk of infection and decided to conduct our workshop at a later stage. In July, we had no choice but to shift the format to an online event on ZOOM, as we were under pressure to meet deadlines for our research results. We had difficulties to mobilize enough participants for the online workshop and had almost 50% fewer registrations compared to the workshop on-site. As a consequence, the relatively low number of participants reduces the significance of the evaluative survey that we conducted during the workshop.

Having published a diverse, informative and multifaceted podcast series on a number of platforms matching different habits of podcast listeners, we will continue to draw attention to our recordings. Given that TUM’s involvement in Africa is just at the beginning, we are convinced that our podcast recordings can help to inform students about different collaboration projects between TUM and KNUST.

In addition to what we call “*passive interest*”, we aim to stimulate the listeners’ “active interest.” We hope to motivate students to participate proactively in research projects, internships abroad or exchange semesters. Over the past twenty months, Africast has been in contact with many people involved in such projects and, hence, we want to support passionate students in realizing their ambitions for African research projects. Whether TUM students need more information about existing initiatives or first-hand advice from students and professors of KNUST – we are happy to connect and help in every possible way. ■

Figure 4.2.1: Team Africast with university delegates from the Kwame Nkrumah University of Science and Technology

References

- Akyeampong, E. (1999). *Christianity, modernity and the weight of tradition in the life of Asantehene Agyeman Prempeh I, c. 1888-1931*. International African Institute, pp. 279-311.
- Alabi, G. and Mohammed, I. (2018). *Research and PhD capacities in sub-Saharan Africa. Ghana Report.* Retrieved 25.08.2020 from https://www.britishcouncil.org/sites/default/files/h233_04_research_and_phd_capacities_in_sub_saharan_africa_ghana_report_final_web.pdf.
- Domenichini, B. (2018). *Podcastnutzung in Deutschland*. Retrieved 02.09.2020 from https://www.ard-werbung.de/fileadmin/user_upload/media-perspektiven/pdf/2018/0218_Domenichini.pdf
- Frayha, N., Brown, J., and Parker, D. (2019). A student affairs podcast as novel communication tool. *Canadian Medical Education Journal, 10* (4).
- Garner, R., and Gillingham, M. G. (1991). Topic knowledge, cognitive interest, and text recall: A microanalysis. *The Journal of Experimental Education, 59* (4), pp. 310-319.
- German Federal Ministry for Economic Cooperation and Development (2020). *A Marshall Plan with Africa.* Retrieved 01.08.2020 from https://www.bmz.de/en/countries_regions/marshall_plan_with_africa/index.html.
- Guilford, J. P., Christensen, P. R., Bond Jr, N. A., and Sutton, M. A. (1954). A factor analysis study of human interests. *Psychological monographs: General and applied, 68* (4), 1.
- Habermas, J. (2015). *Knowledge and human interests.*
- Jham, B. C., Duraes, G. V., Strassler, H. E., and Sensi, L. G. (2008). Joining the podcast revolution. *Journal of Dental Education,* 72 (3), pp. 278-281.
- KNUST (2020a). About us. Retrieved 31.08.2020 from https://www.knust.edu.gh/about.
- KNUST (2020b). *University history.* Retrieved 31.08.2020 from https://www.knust.edu.gh/about/knust/history.
- KNUST (2020c). *Campus facilities.* Retrieved 31.08.2020 from https://www.knust.edu.gh/students/facilities.
- Observatory of Economic Complexity (2018). *Ghana.* Retrieved 25.08.2020 from https://oec.world/en/profile/country/gha.
- Rainsbury, J. W., and McDonnell, S. M. (2006). *Podcasts: an educational revolution in the making?, Journal of the Royal Society of Medicine, 99* (9), pp. 481-482.
- Salisbury, R. H. (1969). An exchange theory of interest groups. *Midwest journal of political science,* 1-32.
- Shillington, K. (1995). *History of Africa.* St. Martin’s.
- Siabi-Mensah, K., Badu-Nyarko, S. K. and Torto, B. A. (2009). *Problems of part-time students in Ghana. Implications for distance education.* Turkish Online Journal of Distance Education 10 (4).
- Standard Bank (2011). *African markets revealed.* Retrieved 25.08.2020 from https://biz-file.com/f/1101/10168_1.PDF.
- Technical University of Munich (2020). *TUM starts long-term Africa initiative.* Retrieved 01.08.2020 from https://www.tum.de/nc/en/about-tum/news/press-releases/details/35124/.
- Trading Economics (2020a). *Ghana – Public spending on education. Total (% of government Expenditure).* Retrieved 25.08.2020 from https://tradingeconomics.com/ghana/public-spending-on-education-total-percent-of-government-expenditure-wb-data.html.
- Trading Economics (2020b). *Ghana – School enrollment. Tertiary (% Gross).* Retrieved 25.08.2020 from https://tradingeconomics.com/ghana/school-enrollment-tertiary-percent-gross-wb-data.html.
- Trading Economics (2020c). *Ghana - Total outbound internationally mobile tertiary students studying abroad. All countries, both sexes.* Retrieved 25.08.2020 from https://tradingeconomics.com/ghana/total-outbound-internationally-mobile-tertiary-students-studying-abroad-all-countries-both-sexes-number-wb-data.html.
- University of Ghana (2018). *Enrolment and graduation statistics.* Retrieved 25.08.2020 from https://www.ug.edu.gh/about/enrolment-and-graduation-statistics.
- U.S. News (2019). *Best global universities.* Retrieved 31.08.2020 from https://www.usnews.com/education/best-global-universities/kwame-nkrumah-university-science-technology-529441.
- World Population Review (2020). *Kumasi population 2020.* Retrieved 31.08.2020 from https://worldpopulationreview.com/world-cities/kumasi-population.

Self Reflection

Back in November 2018, we started as a team of five students with diverse study backgrounds: Political science, mathematics, electrical engineering, robotics and engineering science. Our initial idea was to create a platform for students that depicts how different electives at TUM are linked in order to facilitate the choice of electives across various disciplines.

In retrospect, the lack of team experience might have been one reason why we did not achieve progress throughout the first months with the "StudyNav" platform. We had intense discussions and a variety of ideas but failed to implement any of them. Three months into the project, in January 2019, one of our team members decided to leave the TUM: Junge Akademie.

Despite this setback, we decided to stick together as a team and to focus on a new project. As a team of four, we quickly established an honest and transparent way of communication and discovered the potential strengths of a small group, including effective team meetings, easy coordination and task sharing and fewer disagreements about the project work.
When we were first introduced to the Africa initiative of the Technical University of Munich, all of us were immediately interested in starting a research project in this context. We quickly identified the key problem that most students at TUM are not well informed about the university's partnerships and initiatives in Africa. Next, we defined an online podcast series as the adequate instrument to share that information with TUM students.

Within a few weeks, we set up a broad network with the TUM International Center, the Ghana Students Union-Munich and TUM professors who are involved in research projects on the African continent. Furthermore, we had the opportunity to meet KNUST university delegates in Munich and to pitch our project on this occasion. Throughout the exchange with stakeholders, we always received positive feedback and encountered broad interest for the podcast series Africast.

From left to right: Patrick Sowinski (Team Africast), Dr. Samuel Dodoo (Podcast guest, episode 5), Jaimee Lau (Team Africast), Marius Merkle (Team Africast), Dipl.-Ing. Johannes Winklmaier (Podcast guest, episode 4) and Prof. Dr. Walter de Vries (Podcast guest, episode 6)

In the following months, we successfully organized the first podcast recordings in a professional studio and planned the release on different online platforms.

However, a few days before our final podcast recording, another team member decided to leave the TUM: Junge Akademie as he could no longer identify himself with our project. This came as quite a surprise, since we had always tried to make sure that everybody was on the same page with project Africast and we had agreed to try to overcome the difficulties of a small team by putting in extra work and motivation.

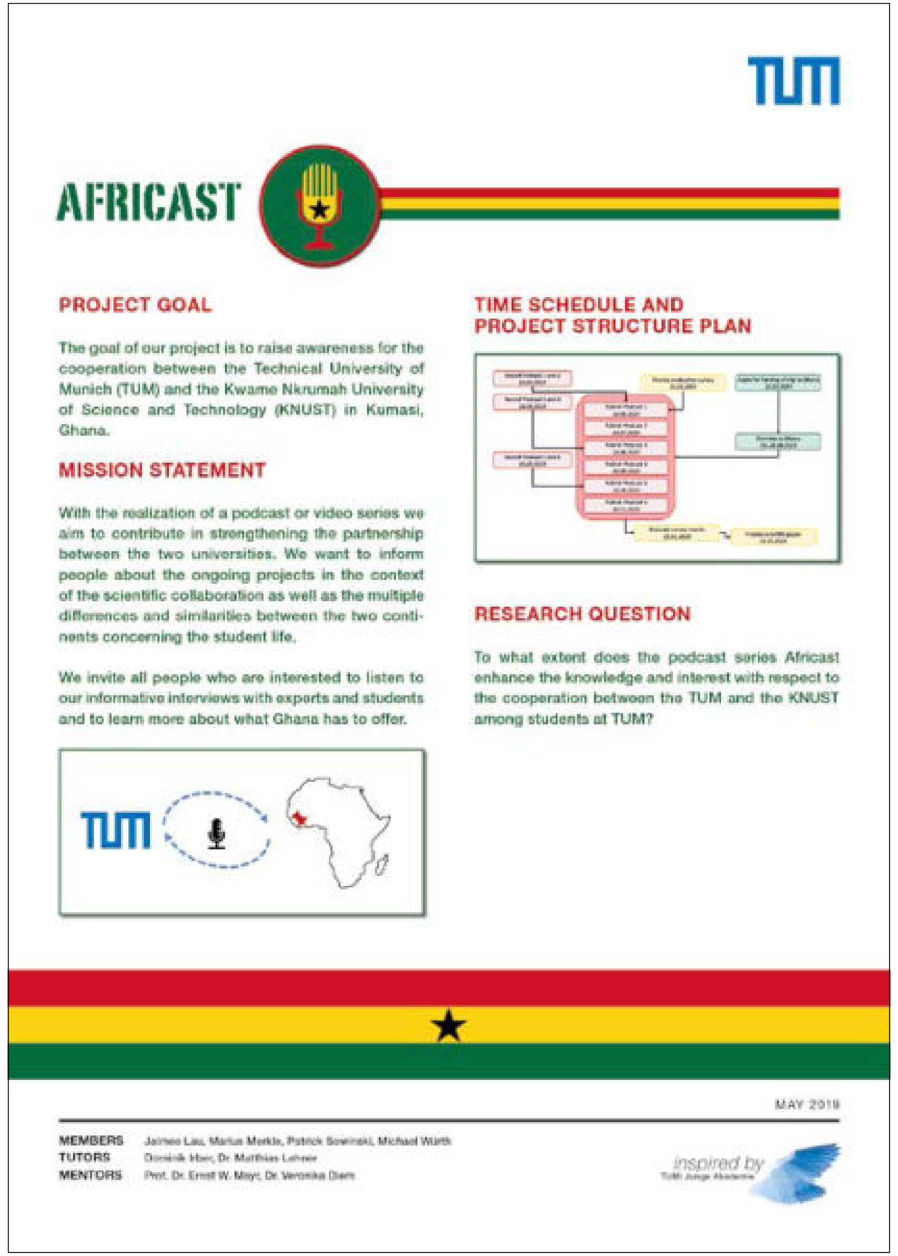
Again, we were able to overcome this challenge and to complete the Africast project as a team of only three students. Especially while team members were abroad and located in different time zones, the project work proved to be difficult. During this time, we benefited from the small size of our team, as it facilitated compromises and the management of tasks and meetings.

The successful navigation through the entire project as well as the dynamic team environment was also largely possible thanks to the continuous support of our two mentors and two supervisors.

Our mentors, Matthias Lehner and Dominik Irber, hardly missed a meeting and always made sure that we were moving in the right direction. They gave us a lot of freedom during brainstorming meetings, while also knowing when to intervene and help us get back on track.

Our supervisors, Veronika Diem and Ernst Mayr, always challenged our assumptions and gave constructive feedback. The most constructive discussions took place at our bi-monthly meetings with our supervisors. They encouraged us to rethink and inspired us in many ways. ■

From left to right: Patrick Sowinski (Team Africast) in the recording studio with Dr. Samuel Dodoo (Podcast guest, episode 5)



TUM

AFRICAST

PROJECT GOAL

The goal of our project is to raise awareness for the cooperation between the Technical University of Munich (TUM) and the Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi, Ghana.

MISSION STATEMENT

With the realization of a podcast or video series we aim to contribute in strengthening the partnership between the two universities. We want to inform people about the ongoing projects in the context of the scientific collaboration as well as the multiple differences and similarities between the two continents concerning the student life.

We invite all people who are interested to listen to our informative interviews with experts and students and to learn more about what Ghana has to offer.

TIME SCHEDULE AND PROJECT STRUCTURE PLAN

RESEARCH QUESTION

To what extent does the podcast series Africast enhance the knowledge and interest with respect to the cooperation between the TUM and the KNUST among students at TUM?

MAY 2019

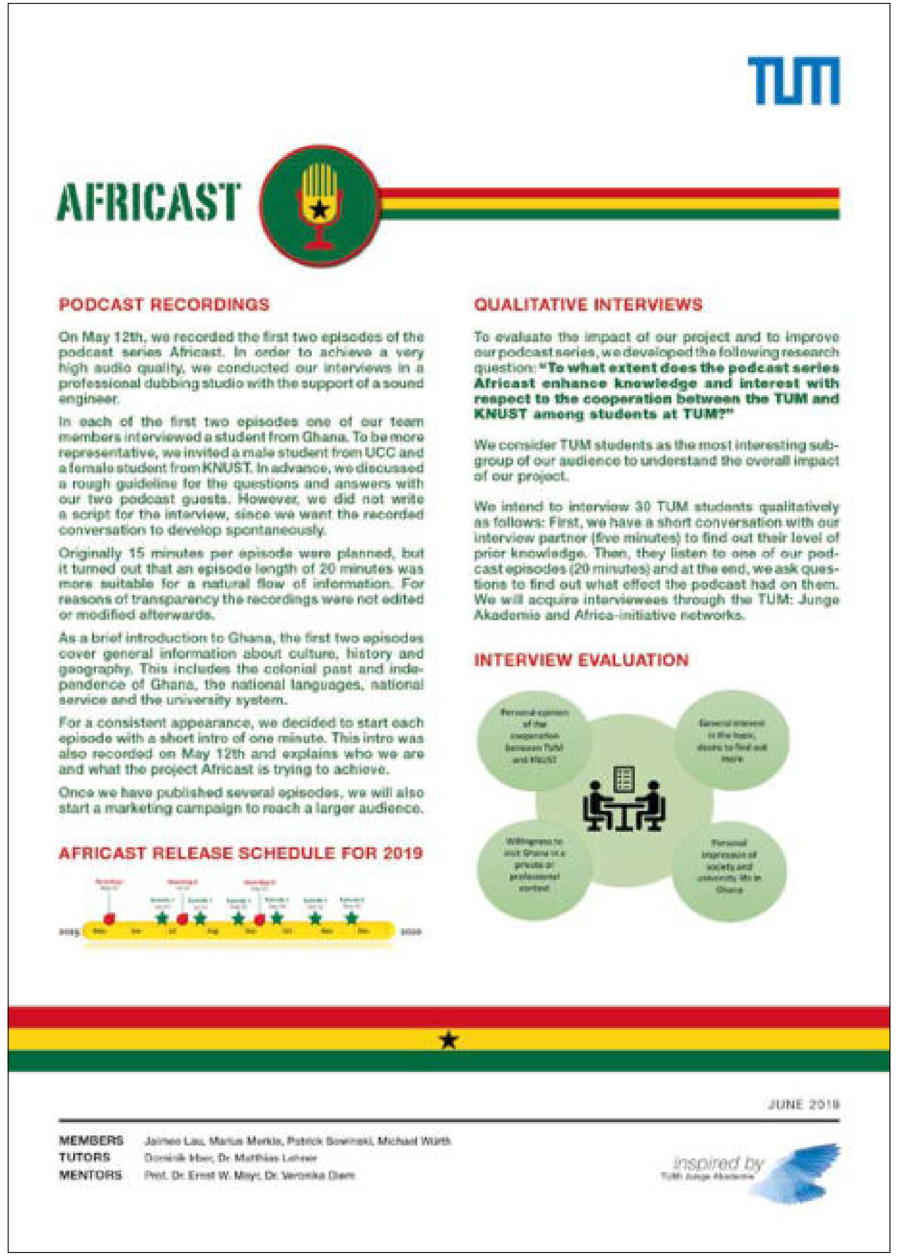
MEMBERS Jaimee Lau, Marius Merkle, Patrick Sowinski, Michael Würth
TUTORS Dominik Irber, Dr. Matthias Lehner
MENTORS Prof. Dr. Ernst W. Mayr, Dr. Veronika Diem

inspired by TUM: Junge Akademie

POSTER 1: The first poster presented the bigger picture of the project Africast. In view of the growing involvement of TUM in various scientific projects in Africa, we decided to start a project related to this development. We realized that many TUM students are not informed about TUM's Africa initiative, but would be very interested to learn about cross-border projects, research and exchange opportunities in this context. However, TUM's involvement in Africa is extremely diverse and multifaceted and can hardly be summarized concisely without neglecting important information. To limit the range of possible topics, we decided to focus on Ghana and the collaboration between TUM and KNUST, which is of particular importance within the Africa initiative.

In a second step, an appropriate and effective medium of communication had to be defined. We agreed to choose interactive interviews in the form of podcasts, primarily for their recent rise in popularity among young adults and students. A detailed scientific reasoning for podcasts as a form of communication can be found in the scientific part of the project report.

As we are interested in the effect of our podcast series, the goal was to evaluate at the end of the project phase how the audience perceived the episodes and whether we could transfer knowledge and spark interest. ■



TUM

AFRICAST

PODCAST RECORDINGS

On May 12th, we recorded the first two episodes of the podcast series Africast. In order to achieve a very high audio quality, we conducted our interviews in a professional dubbing studio with the support of a sound engineer.

In each of the first two episodes one of our team members interviewed a student from Ghana. To be more representative, we invited a male student from UCC and a female student from KNUST. In advance, we discussed a rough guideline for the questions and answers with our two podcast guests. However, we did not write a script for the interview, since we want the recorded conversation to develop spontaneously.

Originally 15 minutes per episode were planned, but it turned out that an episode length of 20 minutes was more suitable for a natural flow of information. For reasons of transparency the recordings were not edited or modified afterwards.

As a brief introduction to Ghana, the first two episodes cover general information about culture, history and geography. This includes the colonial past and independence of Ghana, the national languages, national service and the university system.

For a consistent appearance, we decided to start each episode with a short intro of one minute. This intro was also recorded on May 12th and explains who we are and what the project Africast is trying to achieve.

Once we have published several episodes, we will also start a marketing campaign to reach a larger audience.

AFRICAST RELEASE SCHEDULE FOR 2019

QUALITATIVE INTERVIEWS

To evaluate the impact of our project and to improve our podcast series, we developed the following research question: **"To what extent does the podcast series Africast enhance knowledge and interest with respect to the cooperation between the TUM and KNUST among students at TUM?"**

We consider TUM students as the most interesting subgroup of our audience to understand the overall impact of our project.

We intend to interview 30 TUM students qualitatively as follows: First, we have a short conversation with our interview partner (five minutes) to find out their level of prior knowledge. Then, they listen to one of our podcast episodes (20 minutes) and at the end, we ask questions to find out what effect the podcast had on them. We will acquire interviewees through the TUM: Junge Akademie and Africa-initiative networks.

INTERVIEW EVALUATION

Personal opinion of the cooperation between TUM and KNUST

General interest in the topic, desire to find out more

Willingness to visit Ghana in a private or professional context

Personal impression of society and university life in Ghana

JUNE 2019

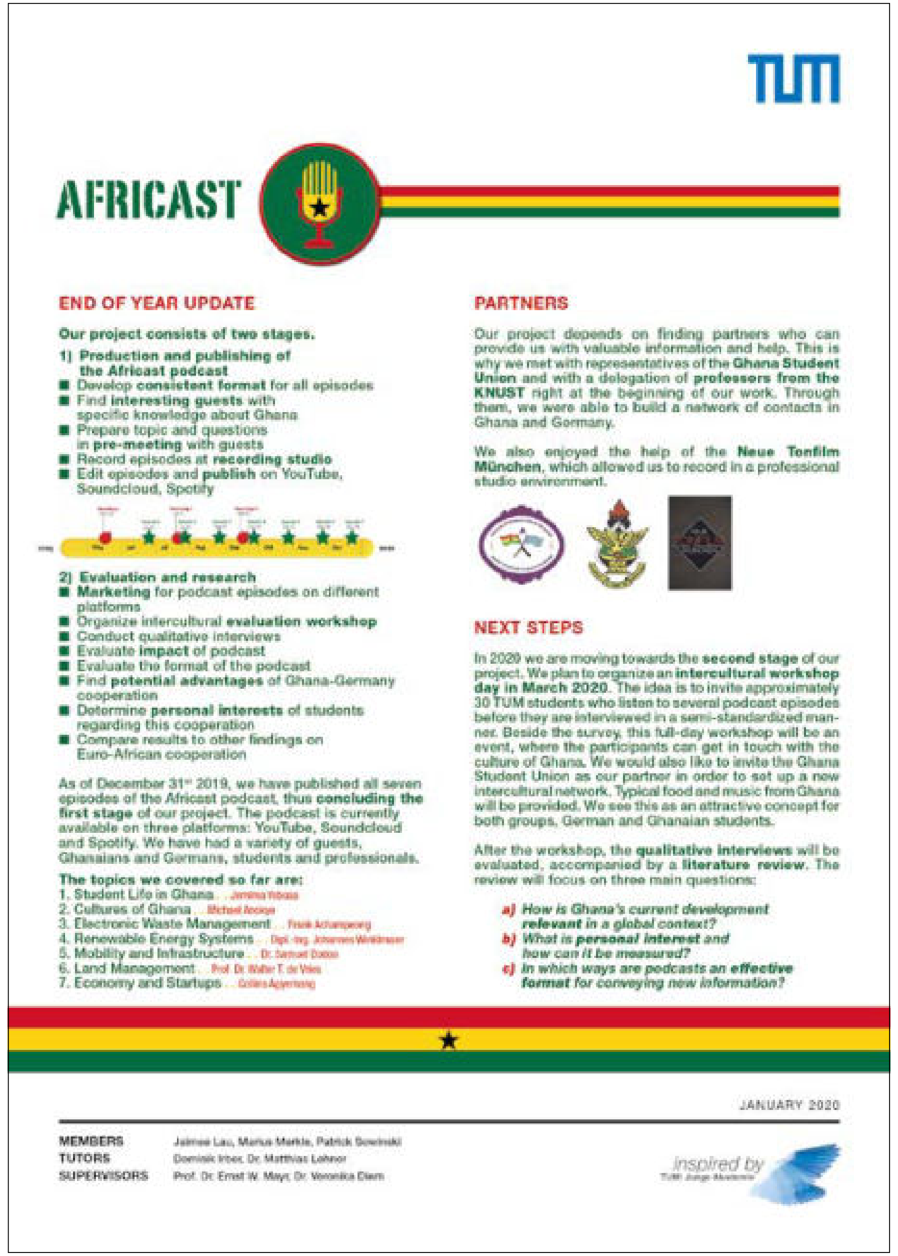
MEMBERS Jaimee Lau, Marius Merkle, Patrick Sowinski, Michael Würth
TUTORS Dominik Irber, Dr. Matthias Lehner
MENTORS Prof. Dr. Ernst W. Mayr, Dr. Veronika Diem

inspired by TUM: Junge Akademie

POSTER 2: Despite the fact that the second poster followed the first just one month later, we had a lot of new updates to share. Looking back, the summer of 2019 was the most intense phase of our project. During this time, we worked in particular on the preparation of the different podcast episodes and on the recordings with the guests. We produced the first two podcast episodes in a professional dubbing studio in May 2019. Overall, we planned to publish a set of seven podcast episodes, covering a diverse range of topics. Since we felt that a brief introduction to Ghana would enhance the effect of the consecutive episodes, we provide a general introduction about the culture and history of Ghana in the first two episodes of the series.

Planning ahead, we presented a preliminary release schedule. The intention was to publish at regular intervals so that the audience had enough time to listen to each podcast episode.

Meanwhile, we presented significant progress in our scientific evaluation methodology. After intense discussions with our mentors and supervisors, we specified how qualitative interviews help to stimulate the knowledge and interest of the listeners. We planned to interview the listeners before and after listening to a specific podcast episode and to compare the prior and posterior answers, focusing on *active interest, passive interest* and *factual knowledge.* ■



AFRICAST

END OF YEAR UPDATE

Our project consists of two stages.

1) Production and publishing of the Africast podcast

- Develop **consistent format** for all episodes
- Find **interesting guests** with specific knowledge about Ghana
- Prepare topic and questions in **pre-meeting** with guests
- Record episodes at **recording studio**
- Edit episodes and **publish** on YouTube, Soundcloud, Spotify

2) Evaluation and research

- **Marketing** for podcast episodes on different platforms
- Organize intercultural **evaluation workshop**
- Conduct qualitative interviews
- Evaluate **impact** of podcast
- Evaluate the format of the podcast
- Find **potential advantages** of Ghana-Germany cooperation
- Determine **personal interests** of students regarding this cooperation
- Compare results to other findings on Euro-African cooperation

As of December 31st 2019, we have published all seven episodes of the Africast podcast, thus **concluding the first stage** of our project. The podcast is currently available on three platforms: YouTube, Soundcloud and Spotify. We have had a variety of guests, Ghanaians and Germans, students and professionals.

The topics we covered so far are:

1. Student Life in Ghana … Jemima [illegible]
2. Cultures of Ghana … Michael Anokye
3. Electronic Waste Management … Frank Acheampong
4. Renewable Energy Systems … Dipl.-Ing. Johannes Winklmaier
5. Mobility and Infrastructure … Dr. Samuel Dotse
6. Land Management … Prof. Dr. Walter T. de Vries
7. Economy and Startups … Collins Agyemang

PARTNERS

Our project depends on finding partners who can provide us with valuable information and help. This is why we met with representatives of the **Ghana Student Union** and with a delegation of **professors from the KNUST** right at the beginning of our work. Through them, we were able to build a network of contacts in Ghana and Germany.

We also enjoyed the help of the **Neue Tonfilm München**, which allowed us to record in a professional studio environment.

NEXT STEPS

In 2020 we are moving towards the **second stage** of our project. We plan to organize an **intercultural workshop day in March 2020**. The idea is to invite approximately 30 TUM students who listen to several podcast episodes before they are interviewed in a semi-standardized manner. Beside the survey, this full-day workshop will be an event, where the participants can get in touch with the culture of Ghana. We would also like to invite the Ghana Student Union as our partner in order to set up a new intercultural network. Typical food and music from Ghana will be provided. We see this as an attractive concept for both groups, German and Ghanaian students.

After the workshop, the **qualitative interviews** will be evaluated, accompanied by a **literature review**. The review will focus on three main questions:

a) *How is Ghana's current development **relevant** in a global context?*
b) *What is **personal interest** and how can it be measured?*
c) *In which ways are podcasts an **effective format** for conveying new information?*

JANUARY 2020

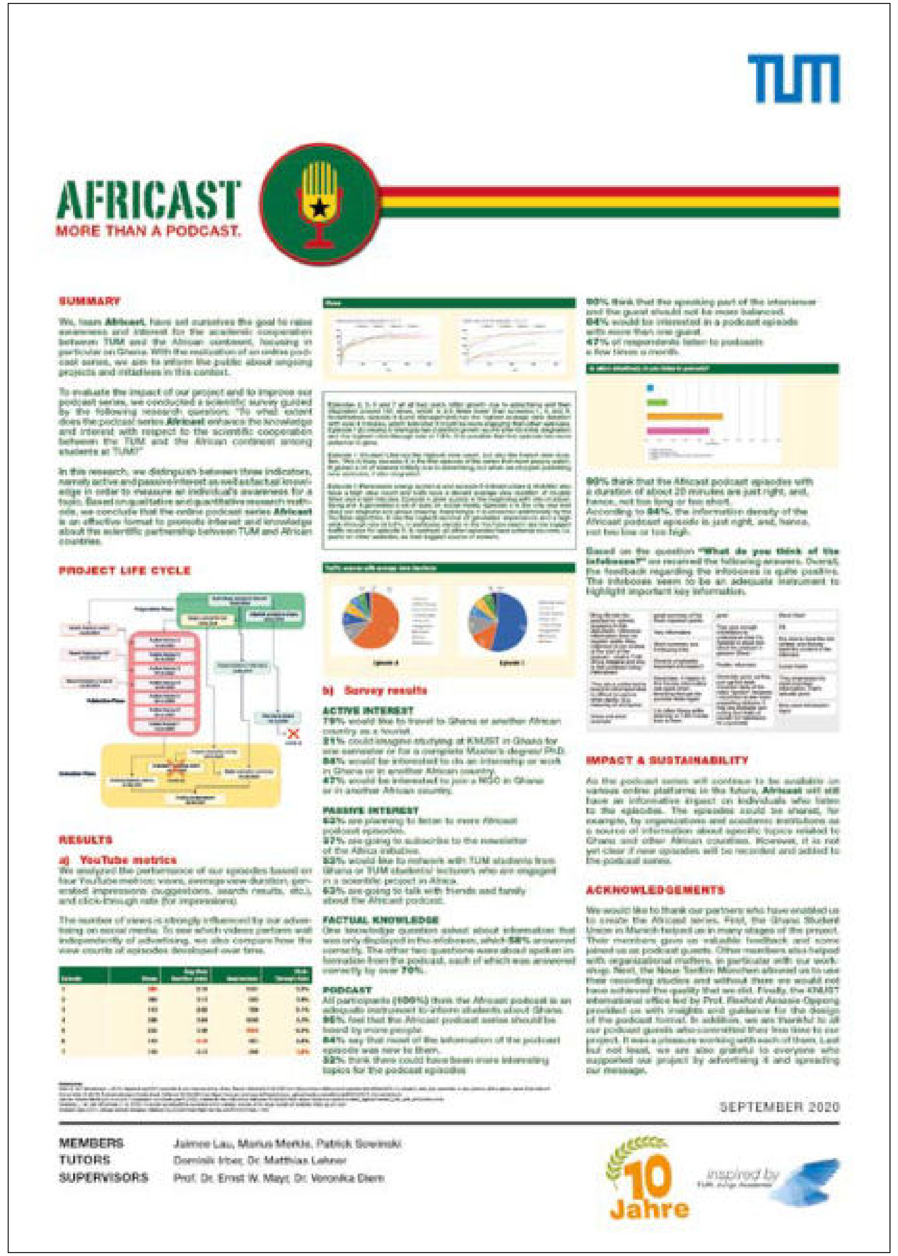
MEMBERS Jaimee Lau, Marius Merkle, Patrick Sowinski
TUTORS Dominik Irber, Dr. Matthias Lehner
SUPERVISORS Prof. Dr. Ernst W. Mayr, Dr. Veronika Diem

POSTER 3: In January 2020, we had finished the recording of the whole podcast series and provided an overview of the topics and the interview guests of each episode. Besides this, we updated our release schedule by adding an additional seventh podcast episode about the economy and startups in Ghana.

The podcasts series is characterized by its standard format: Each episode starts with an intro explaining who we are and what the goal of our project is, and each episode lasts about 20 minutes. To reach a large audience and inform many students from TUM about TUM's Africa Initiative, we were eager to specify a marketing strategy for all different platforms we published on, i.e. Spotify, Soundcloud and YouTube.

Given the international profile of our project, we established an international network and were in close contact with students, professors and researchers from Ghana. With the help of the *Ghana Students Union-Munich*, we recruited many of our interview guests. In March 2019, a delegation of KNUST from Ghana visited TUM and we were able to pitch our project to them and to receive constructive feedback. Finally, we would like to thank "Neue Tonfilm München" for their professional expertise with respect to the recordings. We believe that the exceptional audio quality can enhance the informative effect of the podcast significantly.

Our pre-COVID-19 plans included an in-person workshop in order to conduct the qualitative interviews for the scientific evaluation. The idea was to integrate the Ghana Students Union-Munich into this workshop in order to give the workshop participants an authentic Ghanaian experience. However, we had to cancel the workshop and decided to conduct the workshop in August 2020 as an online workshop with a smaller group of participants, who listened to one podcast episode and filled out an evaluative questionnaire. For the research phase of the project, we defined three main questions to be evaluated based on the result of the survey.



AFRICAST

MORE THAN A PODCAST.

SUMMARY

PROJECT LIFE CYCLE

RESULTS

a) YouTube metrics

b) Survey results

IMPACT & SUSTAINABILITY

ACKNOWLEDGEMENTS

SEPTEMBER 2020

MEMBERS Jaimee Lau, Marius Merkle, Patrick Sowinski
TUTORS Dominik Irber, Dr. Matthias Lehner
SUPERVISORS Prof. Dr. Ernst W. Mayr, Dr. Veronika Diem

10 Jahre
inspired by
TUM: Junge Akademie

POSTER 4: Due to the Covid-19 pandemic, the whole scholarship period as well as the final poster were put back a couple of months. We had to adjust our research steps, in particular with respect to the workshop we had planned to do in person. Yet, with our adapted online approach we were able to analyze the impact and potential success of our podcast series in detail.

In the poster, we share key results from a variety of sources. First of all, we summarize insightful statistics from YouTube, both single numbers regarding statistics such as average view duration and impressions as well as how views evolved over time. Then, we perform a podcast-by-podcast analysis, hypothesizing potential reasons for differences between single episodes. The recordings are compared to each other in terms of the total view development over time as well as their respective traffic source, i.e. the viewer's path to the video. Secondly, we provide an overview of fundamental results of our questionnaires. Throughout different areas, be it active/passive interest, podcast as a form of communication or the use of infoboxes, we received positively engaging feedback overall. We conclude that Africast is an appropriate and effective format to promote the partnership between TUM and KNUST.

Finally, the future impact of our podcast series is briefly assessed and potential use cases for organizations and institutions are outlined. Last but not least, we thank our various partners without whom our project would not have been possible.

DIGITAL
ENLIGHTENMENT

TUM
TUM: Junge Akademie

Project Report **Digital Enlightenment**

Team	Ho Huang Rebeca Marichalar Quezada Xinyi Huang Youssef Walha Yushu Yang
Tutors	Andreas Heimfarth Danilo Hackner
Supervisors	Prof. Dr. Maria Bannert Prof. Dr. Lisa Herzog Prof. Dr. Maximilian Schiffer

Preface by the Tutors 72
Journalistic part 74
Scientific part 78
Self reflection 86
Posters 88

Preface by the Tutors

Danilo Hackner and Andreas Heimfarth

The team Digital Enlightenment started with a bold and broad project goal: improving the way science is communicated. “Are scientific developments relevant to me?”, “Can I trust scientists to tell me the truth?”, “Is it even worth publicly funding science?”, were some interesting questions generated in this process. Highest social relevance had been a driving factor for the team to identify their topic, hence the fact that many people may have accordingly doubts was always an important prerequisite. The COVID-19 pandemic proved, how dangerous it can be if a part of society rejects scientific findings and ignores the corresponding recommendations.

Nevertheless, it was difficult to align on and formulate a concrete project idea and in the end the team developed new thematic approaches together. In this, probably one of the most challenging parts of the entire project, it was impressive to see how a new path was taken through constructive and focused cooperation – even under a certain time pressure. After extensive research the team identified a field both highly relevant and technically challenging to focus on: Educating high school students to manage their data privacy and security. Public discussions about face recognition on social media, large-scale data leaks in corporations and even surveillance by totalitarian countries highlight what can happen if your data gets in the wrong hands. Teenagers are among the most eager users of social media and cloud services, however many of them have little awareness about the risks, as the team’s results show. On the other hand, the topic is complicated and affected by latest developments in science: An encryption technique that is safe today can be obsolete tomorrow due to advancements in math or computer science.

In very short time, the small team developed workshops for 8th to 10th graders and accompanying posters for schools. Simultaneously, they convinced several schools in and around Munich to participate and dedicate time to the teams’ data privacy and security program. We as tutors were amazed by the determination and efficacy they showed in convincing school principals, creating great info material and delivering workshops in English and German without a single native speaker in the team. The team took the approach of fostering discussions and self-reflection with the high-school students rather than lecturing about the “right way” of managing your digital life. The good feedback and observed changes in the teenagers’ attitudes proved them right. The majority of participants reported that data privacy and security topics were not taught in school and that they enjoyed program.

We enjoyed supporting this diverse team in defining their project ambitions and later seeing them achieve their goals very independently. We are sure they have had an enduring influence on the way many of their participants will handle their data in the future. ■

Decode your digital daily life

Shape who you are by only four supermarket receipts.
What more should we know about our digital daily life?

from Ho Huang, Munich

"We often judge people by words they speak, clothes they wear, cars they drive, and their responses in different situations. However, have you ever thought of knowing a person by seeing things they bought from supermarkets on the receipts? How much personal information do you think you can get from them?"

These questions are asked to high school students in a guest workshop by the Junge Akademie project team "Digital Enlightenment" from the Technical University of Munich. Their goal is to convey knowledge and raise awareness of the topic "Data privacy and cybersecurity" to the digital generation.

"We not only want to inform the students about different risks on the Internet, but also how things work in the digital world. So that they would be more aware of their interaction with the digital word and have the ability to assess risks on their own and protect themselves." Says one of the members from the team. After intensive research, interviews with experts from the university and local enterprises, the team Digital Enlightenment sorted out eight popular topics such as AI, hardware defect, data protection regulation, online sharing, activity tracking and so on. Each workshop contains two of the topics and is held either in English or German according to the choice of the school. For students, these workshops will be a special one and half our in their regular English, German, computer or free elective classes.

Data tracking

"I assume the person is very aware of eating healthy because he or she bought a lot of organic products." A boy in the classroom raises his hand grasping a supermarket receipt and says. "and he or she could also be a Muslim since there was no pork product on the list", another girl also makes a guess. The whole class laugh out loud after a student says, "I think this person is a she, because she bought vegetables and fruits, men usually don't do this." What a stereotype! But, would this mean that we can tell the gender of the customers just by counting how much Irish ribeye-steaks they put in the basket?

In reality, by setting the right conditions, and correctly matching, shaping the customer by their purchasing behaviour or predicting their next purchase is not difficult at all using today's technology. Imagine you got an unknown receipt and few things were on the receipt: a face cream, a hair conditioner, one bottle of soybean milk, a package of tofu, 10 organic eggs, 4 yogurts, 2 bottles of tomato sauce, 2 packs of spaghetti and frozen vegetables. Could you give me a guess about the customer's gender, heritage, age range, if he or she is a student, live alone or with partners or family. Does this customer have lactose intolerance?

"She always went to the supermarket around 17:30 or 18:00, we assume she does grocery shopping after work. Oh, and we quickly checked the supermarkets she went to on Google Maps, and we think she either works or lives in the north-west part of Munich." Say one group of students in the workshop at a local high school in Munich.

It is shocking, isn't it? Just by looking at the supermarket receipts, you can already obtain so much information about the customers. Would it be possible to get even more precise information if you had more receipts saved from the same customer for three months, or even one year?

Hardware-hacking and phishing

"Yes! This is a phishing email! We are the first!" A student jumps from the seat, raises his hand and shouts out loud. Here is another workshop with the topic "hardware-tracking and phishing". Students are split up in groups and try to identify different phishing emails and websites by checking if there are obvious grammatical and spelling mistakes, if the names of the companies and institutions are fake, if there is any unusual combination of letters in the link, or any information regarding transferring money to a specific bank account.

We all have experiences where we receive some junk mails in our mailbox or accidently click into some "weird-looking" website when we are browsing on the Internet. The listed check points above are vital information to prevent yourself falling into the phishing trap and eventually "voluntarily" giving out your personal information to hackers. It seems to be easy to avoid phishing, right? In fact, there are almost 1,5 Million phishing websites created every month. And in 2018, scammers stole over 100 million US dollars from Facebook and Google.

"I know my camera is on when I see the green light. So, when somebody is using my camera to watch me, I should know right?" A student holds the camera cover he receives as a give-away from the team and asks. The answer is – not really. It is totally possible that someone turns on your laptop camera without the little green light next to it going on. Students then ask in surprise, "can I have one more camera cover?"

Is there anything else I can do to protect myself from being hacked? Here are some tips recommended by different cybersecurity experts:

Recommended actions	Something we do, but is not really helpful	Do not do
■ Update your apps and operating system ■ Download an anti-virus software on your computer and run the scan on the highest setting ■ Long, strong and unique passwords ■ Turn on the two-factor authentication function ■ Cover your web-cam by using a web-cam sticker ■ Use an ad-blocker	■ Change your password from time to time ■ Use different anti-virus softwares on the same computer ■ Deactivate the web-cam in the computer setting	■ Use same password across different platforms ■ Use the "save your password" function on your browser

“If I don’t use Internet and email, this problem will not exist anymore right?” A student sitting in the first row asked. Unfortunately, not exactly, phishing can also occur without using any specific technology, programming or computer skills. A video is played in the class, showing a woman who is playing the sound of a baby’s cry on YouTube to create a scenario of a busy and stressed mother with a newborn baby, trying to get her husband’s bank information. Guess what? She even managed to change “her husband’s” contact information with the bank in the end. This act of manipulating or tricking someone into divulging information or taking action is called “social engineering”.

Oversharing

While in the break between the workshops, I saw a new post from a friend of mine saying that she just found one hundred Euro in one of the pockets of her winter jacket. It does not really matter to me and to be honest, I am not really interested in every detail of her life. Sometimes, I really think people share way too much information on social media. But does this also have something to do with our digital world?

“Oversharing” refers to when a person gives out more information online about a topic than they would in person. It could be any kind of information, but especially personal information. Nowadays, it is also very common to see companies or celebrities use different online platforms or social media to advertise themselves. But maybe just because of the convenience, people sometimes forget to take the risks into account before they post things on the Internet. Tom Daley, who is an British diver and also the 2012 Olympic bronze medallist, once posted a YouTube video, in which he forgot to cover the phone number while calling his friend Nile Wilson, who is also an Olympic bronze medal artistic gymnast. And guess what, Nile got a lot of unknown messages and phone calls the next day. You might think “not so many people want to get my phone numbers, it shouldn’t be a big deal for us.” But you did post some photos when you were on vacation last year, when you went to Mallorca with your family right? That could be also a risky action because you were basically letting people with certain intensions know that the whole family would not be at home for days.

“Some people share their negative emotion on social media all the time or even suicidal thoughts.” A girl responds when being asked what could be considered as oversharing. The teacher takes the chance and tells the students “if you ever feel depressed or have suicidal thinking, please reach out, no matter if you call somebody or post your thoughts on the internet. In the other case, if you ever see people posting something like this, please show your care, because you might save a life.”

Sharing information is part of our human natures, thanks to the technology and Internet, people can share different information, anytime, anywhere and to anyone. If you want to prevent yourself oversharing, think twice before you hit the “post” button and double check if you accidently reveal personal information online. Set your social media accounts to private, that means only people you know can see your posts, is also an effective way to avoid sharing too much information to strangers.

Conclusion

New information and development of technology are emerging every day at an incredible speed, at the same time, myths and misinformation are everywhere. Our daily living is surrounded by Internet and technology, whereas the knowledge regarding data privacy and cybersecurity is still not commonly covered in our basic education at schools. In an effort to translate scientific information into information and actions which everyone can easily understand and apply, the team Digital Enlightenment from the scholarship program: the TUM Junge Akademie is putting their ideas into action and trying to bridge the gap between science and our daily lives.

We make life easier, but ...
Data Tracking.
What does the world know about you?
Social Media and Oversharing.
#TMI – Too Much Information
Hacking is not science fiction, neither a paranoia. It's real!
Hardware hacking and Cybersecurity.
Hacking is not science fiction, neither a paranoia.
Hardware hacking and Cybersecurity.
We make life easier, but ...
Data Tracking.
I know what you are thinking ...
AI and Cybersecurity.

The posters are displayed around the campus and in the cooperated high school before the workshop

Digital Enlightenment

Table of contents:

Abstract

1. Background: The Importance of Cybersecurity And Data Privacy

2. Goals and Methods Short intro of goals and then proceed to 2.1 and 2.2
   2.1 Interviews of Professor and Experts ()
   2.2 Workshops in Bayerische Gymnasium

3. Outcome and Discussion
   3.1 Analysis of the student behavior
   3.2 Analysis of the survey

4. Summary and Future Goals

References

Abstract

Though the Internet is already indispensable in our daily lives, knowledge regarding data protection and cybersecurity is still not commonly covered in schools. To translate scientific information into easily comprehensible information, our team Digital Enlightenment conducted twelve interactive workshops with almost one hundred and seventy students in four different Munich schools. The topics covered included artificial intelligence, hardware hacking, online sharing and tracked activities. By analyzing pre- and post-survey results, we can conclude that our workshop had a positive impact on students regardless of whether they had had previous training on the topic or not. Besides, more than 60% of students exhibited their willingness to reconsider their online behavior. Based on students' behavior in the workshops, we may also conclude that creating a competitive environment in class has a great potential to boost the students' motivation regarding science communication.

Background

Ever since the inception of the Internet, distance communication and resource sharing have brought people much comfort and convenience. However, in recent years, data scandals of giant companies such as Facebook and Google have cast doubts on personal data protection and cybersecurity. Though the press and governments have exhibited rising concerns about cybersecurity and data protection, the public at large remains either unaware of or complacently indifferent to the potential hazards they may be exposed to. Pew Research Center designed an interactive quiz to answer the question: “What the Public Knows About Cybersecurity.” They found out that many key concepts and topics in terms of cybersecurity are only known by a minority, while most people cannot even correctly answer more than half of the questions (Smith 2017). Responding to the call (2019) "Multimodal Science Communication,” our team Digital Enlightenment decided to empower high school students with the necessary knowledge regarding artificial intelligence, hardware hacking, online sharing and tracked activities. To design successful workshops in each topic, we took interactivity as the most relevant factor, which includes the interaction between student and teacher, the interaction between students themselves, and the interaction between students and workshop materials (Moore 1989). To motivate the students so that they could participate actively in the workshops, we focused on engaging the curiosity of students, explaining the challenge of each topic appropriately, avoiding more work than necessary, and introducing competitive games. These critical factors about intrinsic and extrinsic motivation are mentioned in (Williams-Pierce 2011).

Goals and Methods

As smart gadgets have become indispensable in our daily life, we decided to conduct interactive workshops with incumbent high school students, who are most influenced by digitalization. Surveys were distributed to the students before and after the workshops for effectiveness analysis.

The selected topics include:
1. Artificial Intelligence
2. Hardware Hacking
3. Online Sharing
4. Tracked Activities

Through different workshops, we aim to:
- introduce the topics mentioned above in scientific but understandable terms to the targeted audience;
- raise awareness about cybersecurity among young people;
- determine factors influencing the efficiency of science communication in the field of cybersecurity through the analysis of the outcomes of the implemented actions.

In the following sections, the workshop overviews will be introduced.

Artificial Intelligence (AI)

Though artificial intelligence seems to be a popular topic in our daily conversations, its influence can sometimes be underestimated due to its ubiquity. The workshop aims to motivate students to reconsider their online behavior such as preference settings and the usage of online tools, including Youtube and Instagram, through educating them on how AI works to influence our minds. By incorporating videos and online games into the traditional PowerPoint presentation, the workshop tried to convey the following messages:
1. AI is the codes written by humans. It is intangible. Alexa, Siri or robots should be considered as the carriers of AI.
2. AI works in two ways: follow the rules or learn with data.
3. AI can interpret what we are thinking by evaluating our past data.
4. AI can influence our behavior since it can calculate our interests.

Hardware Hacking

Gadget security is of the utmost importance today since smartphones, tablets and personal computers can be seen in almost every household. This workshop was organized as a competition between different teams. After short introductions about phishing, social engineering and other fun facts, different games and quizzes would follow up to deepen the students’ understanding. The token-winning processes worked to encourage a competitive and highly interactive environment in the class. After the workshop, students should have understood:
1. How much (private) data our devices can store;
2. The dangerous consequences that could result if this data falls into the wrong hands;
3. A brief idea about hacking and how it works;
4. Some advice and tips to help protect their gadgets.

Instead of building an intimidating atmosphere, the workshop encouraged the students to reconsider the protection of their devices based on the knowledge they have acquired.

Online Sharing

As online sharing apps such as Instagram, Snapchat and TikTok become viral, the importance of information protection is brought to the stage. This workshop wants students to reconsider their current behavior on social media by providing information on the risks and benefits of sharing personal information on these platforms. The combination of online quizzes and presentations allowed the presenter to clarify students’ doubts on the spot while maintaining an intermediate level of interactivity throughout the workshop. The main take-aways of the workshop are:
1. What oversharing is;
2. The risks, benefits and limits of sharing private information on social media.

Tracked Activities

It is a typical phenomenon when a freshly downloaded app asks us for permission to track our voices, locations and photos. How would these tracked activities affect our daily life? This workshop aims to share what data tracking is and how this relates to our everyday experiences.

After grouping the students into different teams, different datasets from our daily life were given to them. Students were allowed to discuss within their teams to interpret what these datasets could tell them about the data owner. With careful moderation and result-sharing discussion, the students should have been able to learn:

1. Data tracking can make life easier, but at the same time expose us to the danger of data misuse;
2. How data can be used;
3. Data tracking describes how people retrieve data, but its usage depends on the owners of data.

Outcome and discussion

After carrying out twelve workshops with almost a hundred and seventy students in four schools around Munich, our team obtained both pre- and post-survey results regarding the respective workshop topics. The pre-surveys aimed to collect the students' demographic data and their previous knowledge regarding cybersecurity, and the post-surveys allowed the students to rate the overall quality of the workshop. Even though it was not possible to ask all the students in every school to answer the questionnaires – due to school regulations – at the end of the project, forty-four students filled out our surveys. Most of the students who participated in the workshop were between 15 and 16 years old (see Fig. 1).

Thanks to the surveys, it was possible to understand the students' overall Internet behavior. Most students (72.7%) own either two or three devices with which they access the Internet; however, a few have four or even more than four devices (18.2%) (see Fig. 2). Most of them spend two to three hours daily online (see Fig. 3). Both Figures 1 and 2 show that high school students are indeed subject to frequent data exchange, proving the necessity to empower them with a deeper understanding of cybersecurity. Figure 4 shows that they usually access the Internet at their home. This phenomenon could be caused by the restriction of Internet usage in some schools.

Age of students in workshops

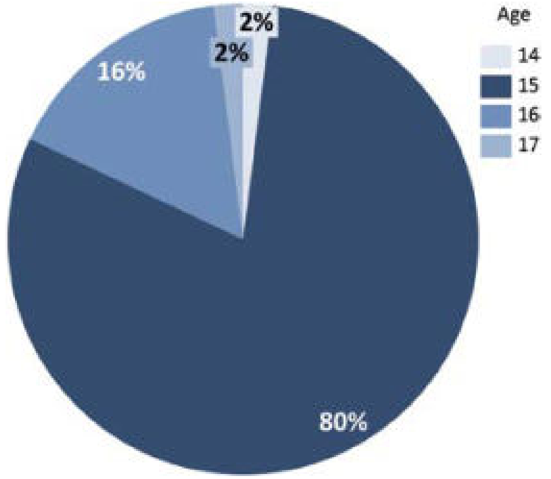


Fig. 1. Percentage of students by age

Number of devices owned per student

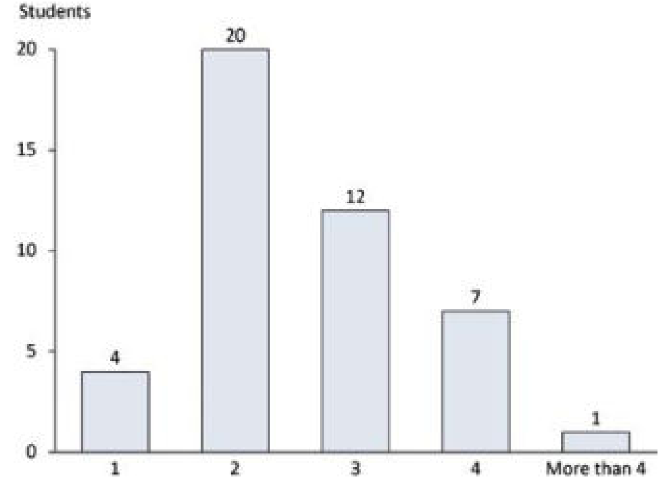


Fig. 2. Number of devices owned per student

When asking students about their main activities online, watching videos, listening to music and social media are the most common answers (see Fig. 5). Studying and browsing for information are also common, but not as much as the previously mentioned activities. Hence, it is essential to provide high-quality information to students on what kind of consequences their online behavior could have.

In general, good feedback was received from students regarding the workshop. 97% of them rated the workshop as good or very good (see Fig. 6).

Students were also asked whether the workshop satisfied their expectations on a Likert scale from 1 to 5 (1 = “Completely,” 5 = “Not at all”). On average, the workshop scored 1.92, meaning that the expectations of students were mostly satisfied. The students also evaluated whether the workshop was interesting, fun, important and clear. On a scale from 1 to 5 (1 = “Very Much,” 5 =” Not at all”), the workshop performed better on the categories of importance (M=1.34) and clearness (M=1.52). The category fun was also positively evaluated (M=1.63). However, the category of newness was the least highly rated (M=2.45).

One of the main goals of the project was to find out whether giving an interactive workshop on a new topic could increase students' knowledge. Within the sample, 50% of the students asserted they had previously participated in cybersecurity or data training, while 50% had no previous experience (see Fig. 7). The knowledge of some cybersecurity concepts was evaluated through questions (within the topics of Online Sharing, Hardware Hacking, Data Tracking and AI). It was hypothesized that students with previous knowledge would perform better than students who were being exposed to such training for the first time.

To examine the validity of this hypothesis, the percentage of correctly answered questions for both groups was assessed. On average, students with previous training answered correctly to 68% of the questions, while students with no previous training answered

Number of hours per day spent online

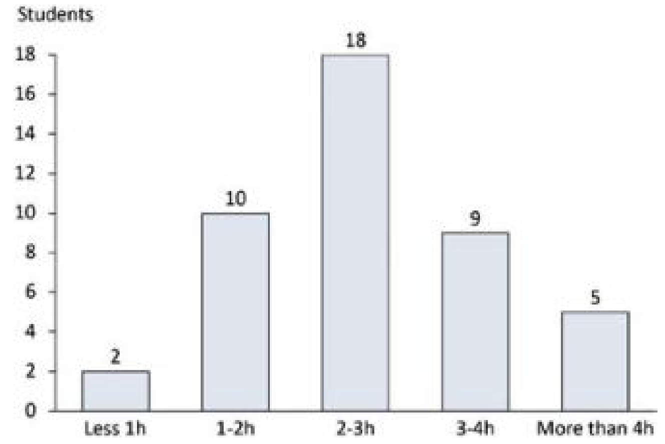


Fig. 3. Average amount of hours spent online per day

Main place to use the Internet

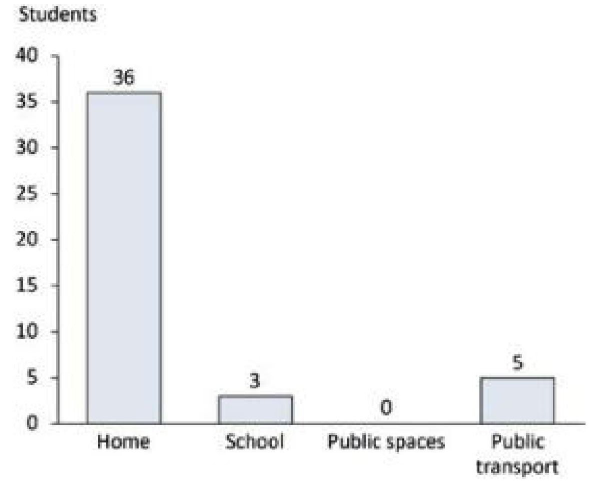


Fig. 4. Main places where students use the Internet

correctly to 73% of the questions. Even though students with no previous training had a higher proportion of correct answers, this difference was not significant between the groups, z=-0.364, p=.719.

For our project, it was also critical to assess whether students had learned something at the end of the workshop. The surveyed students were asked to indicate whether they felt they had learned "a lot," "a little" or "nothing." The difference between the group with previous training and the one without was very slight. Although 5% of the students with previous training said they did not learn anything new, the majority of students asserted that they had learned a little or a lot (see Fig. 8).

To further rate the success of the workshop, students' future willingness to change their behavior was measured. It was hypothesized that to consider the workshop successful at least 40% of the students should state their willingness to re-evaluate their behavior. At the end of the test, 61.36% of the surveyed students said they would like to reconsider their online behavior. This percentage was significantly greater than the 50% hypothesized, z=-2.90, p<.05. In conclusion, the workshops were successful in motivating students to reconsider their daily online behavior.

From surveying the students, our team learned that students between 14 and 17 years spend a considerable amount of time online through several devices and that they mostly use the Internet at

Popularity of internet activities

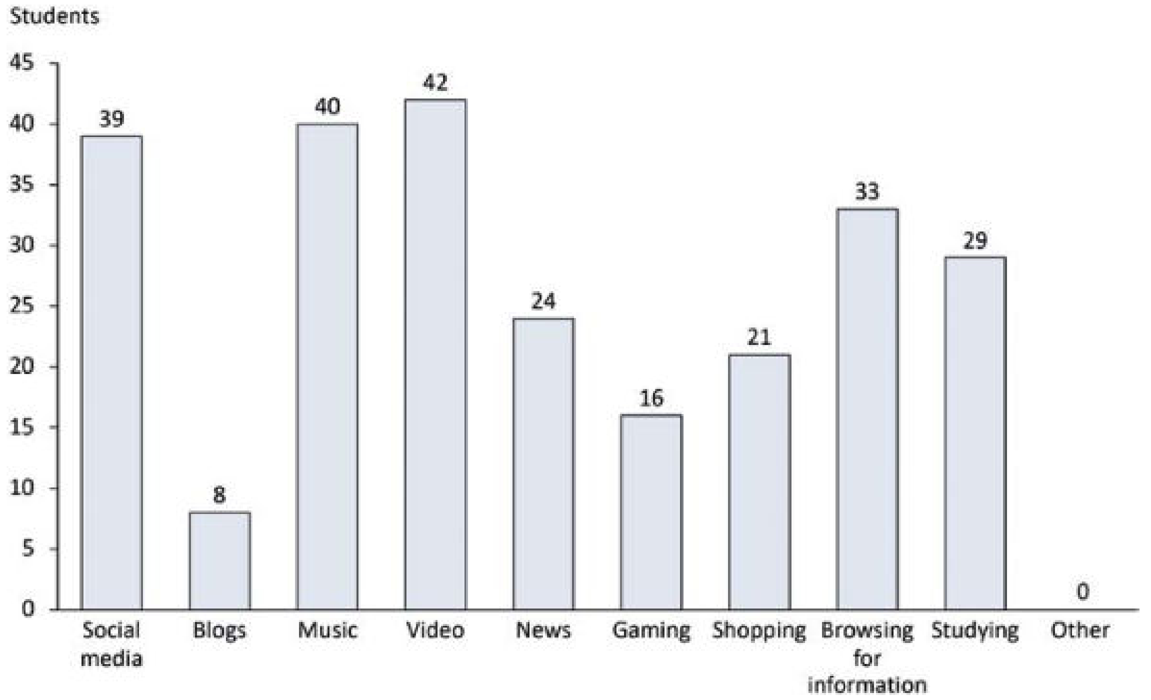


Fig. 5. Main activities on which students spend time online

Rating of the workshops

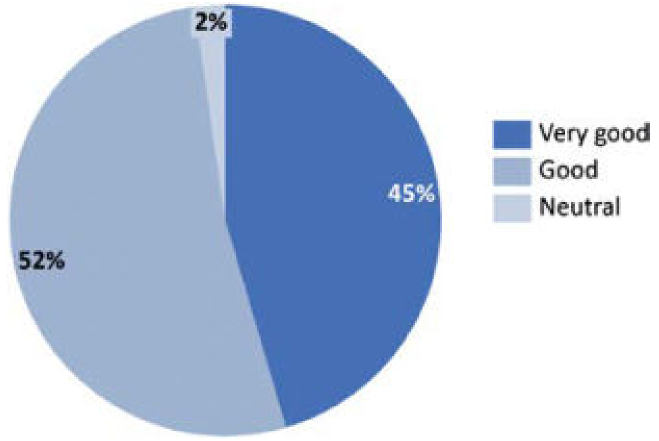


Fig. 6. Rating of the workshops

Students previous knowledge/training

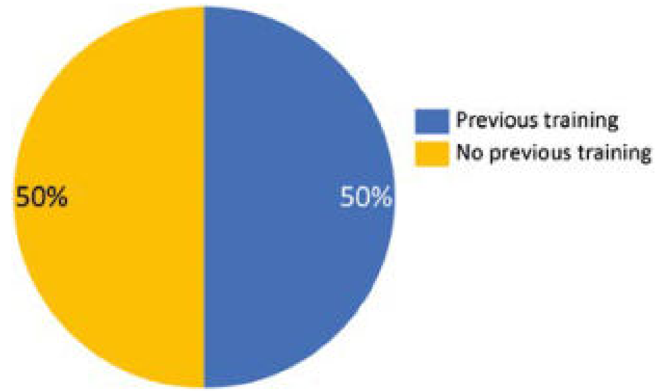


Fig. 7. Previous training on cybersecurity/data privacy topics

Students assessment of workshops: Do you consider you learned something today?

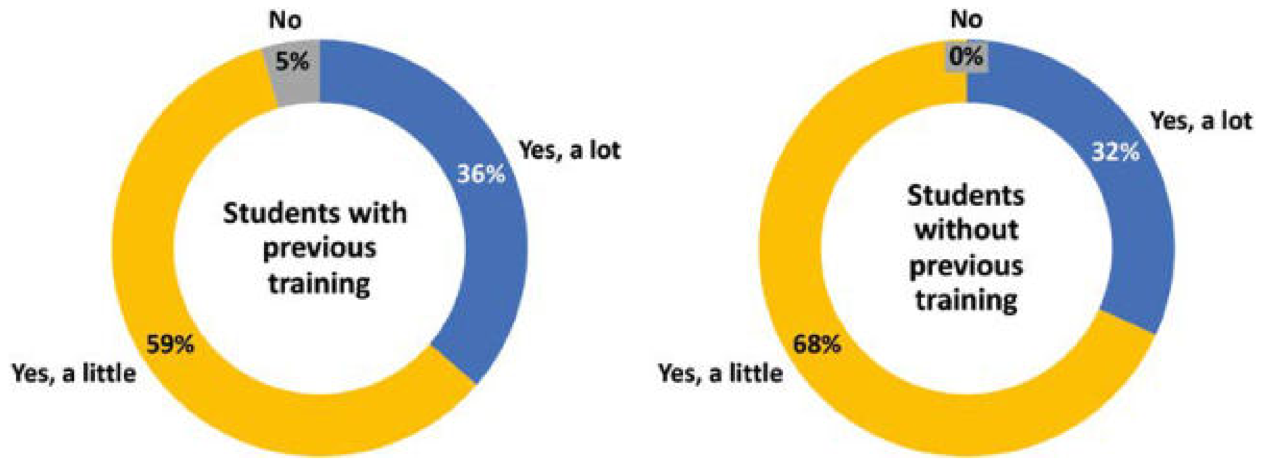


Fig. 8. Learning assessment after workshop: students with previous training vs. students without previous training

home, but seldom in schools and public spaces. In addition, they spend most of their online time on leisure activities; studying and learning new information are secondary activities. These findings reinforce the need to provide students with useful information on how to navigate safely and protect themselves and their personal information on the Internet. Even though some students claimed to have previous training on the topics of cybersecurity and data privacy, the survey results show that their knowledge was not superior to that of untrained students. This phenomenon could mean that the previous training they received was not impactful enough for them to learn basic concepts on the topic.

According to our survey results, very few students considered that they did not learn anything at all during our interactive workshop. The positive evaluation of our workshops could be related to the high willingness of students to reconsider their online behavior, implying that the high degree of interactivity could have had a positive impact on the workshop evaluation. Therefore, we consider that creating these interactive workshops and visiting the schools had a positive impact on the students in their daily lives. Even though it is not possible to assert that there will be a long-term impact on their behavior, motivating students to reconsider their habits is already a significant accomplishment. In the future, providing a permanent source of information directed to young students which takes into account the factor of interactivity could be an excellent opportunity to influence more students and produce a long-term behavioral change.

Summary and Outlook

After conducting twelve workshops in four different Munich schools regarding AI, hardware hacking, online sharing and tracked activities, team Digital Enlightenment tried to motivate students to reconsider their online behavior. Through forty-four survey results, it is clear that students are greatly affected by their online behavior. Whether they are studying online or listening to music, they are constantly in touch with all kinds of information and people during their daily lives. From our survey evaluation, we can conclude that our workshop had a positive impact on students regardless of whether they had previous training on the topic or not. Students with previous knowledge did not perform better than those without pre-knowledge. This phenomenon signals that current training carried out in school or other organizations are not always impactful enough to create long-term learning. In our perception, the environment during the workshops was always very energetic and positive. Using interactive strategies to communicate scientific knowledge about cybersecurity and data privacy, for example, through games and competitions, proved to be a successful method to motivate students. Moreover, even though our team's goal was to convince at least 40% of students to reconsider their behavior, more than 60% asserted that they would be willing to do so.

To ensure a long-term effect and expand the target audience to young people more generally, it might be possible to create a platform which comprises both on- and off-line activities. On such a platform, we could share exciting videos, print materials in the workshops and organize other offline events (see Fig. 9). Not only could the students with workshop experiences revise what they had learned in class, but other internet users could also register to participate in offline activities.

According to our survey results, we would also like to suggest the inclusion of cybersecurity topics in the school curriculum, since the younger generation is subject to vast data exchange every day. Neglecting cybersecurity knowledge in school education could have left the young generation vulnerable to vicious online attacks.

References

- Smith, A. (2017). What the Public Knows About Cybersecurity. *Pew Research Center.* https://www.pewresearch.org/internet/2017/03/22/what-the-public-knows-about-cybersecurity/. Retrieved by August 30, 2020.
- Moore, M. G. (1989). Editorial: three types of interaction. *The American Journal of Distance Education* 3: 1–6.
- Williams, K. C., Williams, C. C. (2011). Five Key Ingredients for Improving Student Motivation. *Research in Higher Education Journal*, 12, p. 1-23.

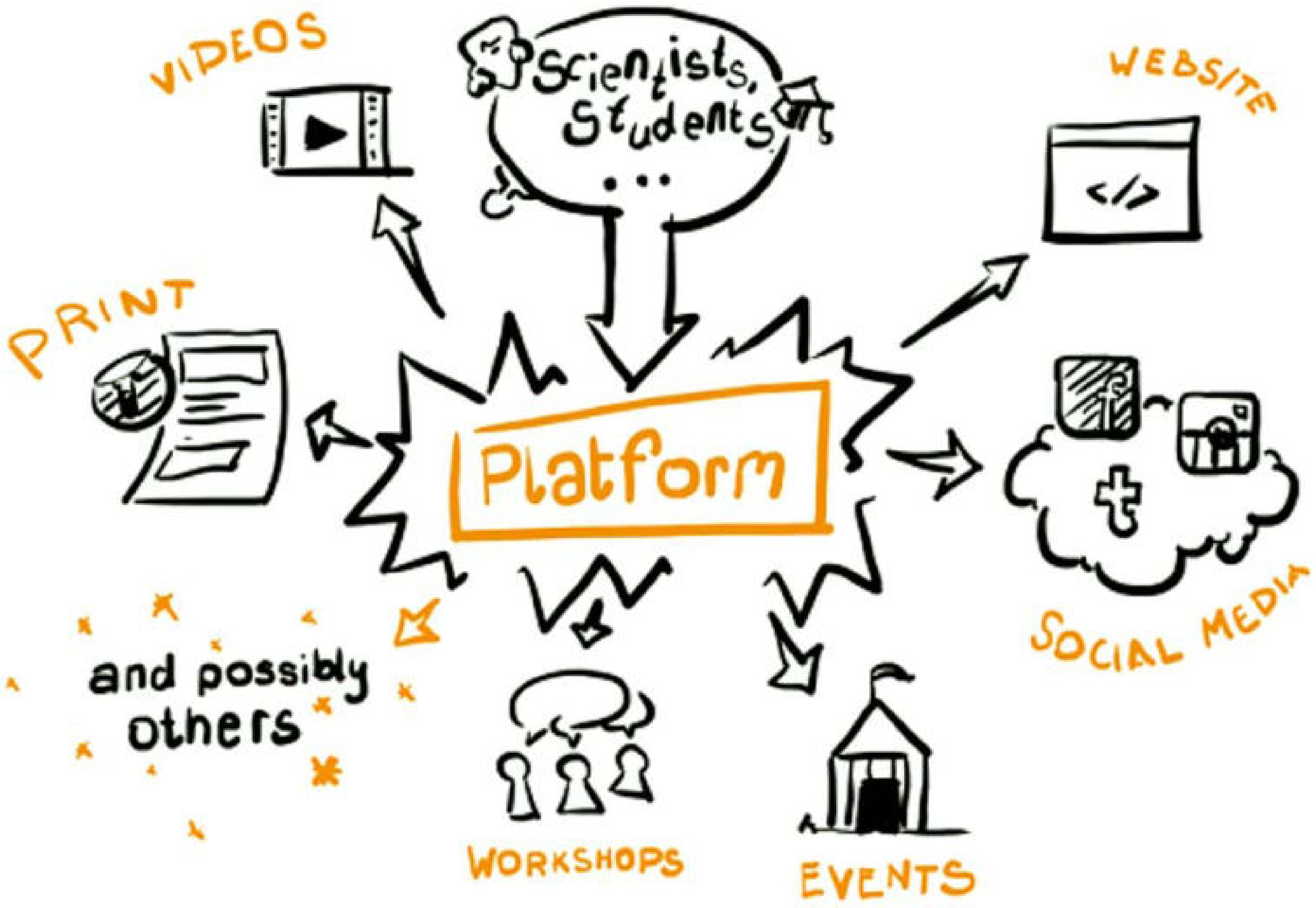


Fig. 9. A multi-media platform for cybersecurity online knowledge sharing and offline activity organisation

Self Reflection

"The beginning is always the hardest" – our experience in Digital Enlightenment was no exception. Determining the theme of our project was exciting yet challenging. We started from a fundamental observation: scientific knowledge in many fields did not adequately reach out to the general public. Therefore, we decided to bridge the gap between science and society. This thought has brought to the birth of our project, "Digital Enlightenment."

To which extent do people need to know about science? Which kind of information is vital to be communicated? Who is the target audience? These are some of the questions frequently appearing in our initial discussions and debates. Science can be inspiring and exciting, but people do have different interests and capacities. Our job was to figure out the topics which the public should but yet have a basic understanding. Initially, we had some other candidates, such as nutrition and climate change, but we ended up choosing cybersecurity and data privacy due to their prevalence in our daily life.

Regarding the target group, the most comfortable choice would have been university students. However, the high school students, who were born and raised in the digitalized era, should be more relevant to cybersecurity. The decision-making process was not as smooth as it might look. We spent a very long time going through possible topics; we hesitated to make decisions because of our high expectations; we started to lose motivation over time. In the end, one of our team members, Markus, decided to leave the project. We were all saddened by his quit. Nevertheless, all the obstacles and hesitations also pushed us forward and let us learn from our mistakes.

After we finally decided to communicate cybersecurity and data privacy to the public, we collected the ten most intriguing questions regarding this topic and conducted a series of interviews, since we wanted to hear from the experts in this field besides the literature research by ourselves. We initially planned to have talks with experts in universities, companies, and organizations, for the diverse background knowledge could help us understand cybersecurity from different perspectives. However, it was tough to get in touch with the company and organization officials. We did not receive any response from them. Fortunately, four professors at TUM accepted our invitation, and we learned a lot from these interviews. They have given us many suggestions and insights. One professor we have interviewed is specialized in the area of science communication. Through that interview, we learned how to present the scientific background of cybersecurity to others more effectively. After extracting the essence from all interviews and research, we decided to focus on eight subtopics from cybersecurity: (1) hardware hacking, (2) tracked activities, (3) is anonymous data secure? (4) how can data protection be secure? (5) why self-initiated data protection measures, (6) sharing online, (7) how AI affects our life, and (8) 5G.

Thanks for the help from Peter and SchaschLEAK, we obtained a list of contact information from high schools around Munich. After careful construction of an invitation letter, we sent them e-mails and asked them to choose the most relevant and intriguing topics for their students. To help the schools decide, individual workshop plans were drafted and sent to them, indicating the workshop's format, duration, and content. We included teaching methods, teaching aids, workshop language (given that our group is only made up of international students), and detailed workshop plans. Each workshop was planned to last around 30 min. Interestingly, most schools chose topics 1, 2, 6, and 7. All of the schools also decided to book more than one workshop, implying that the workshop plans and information we have presented were considered relevant and essential.

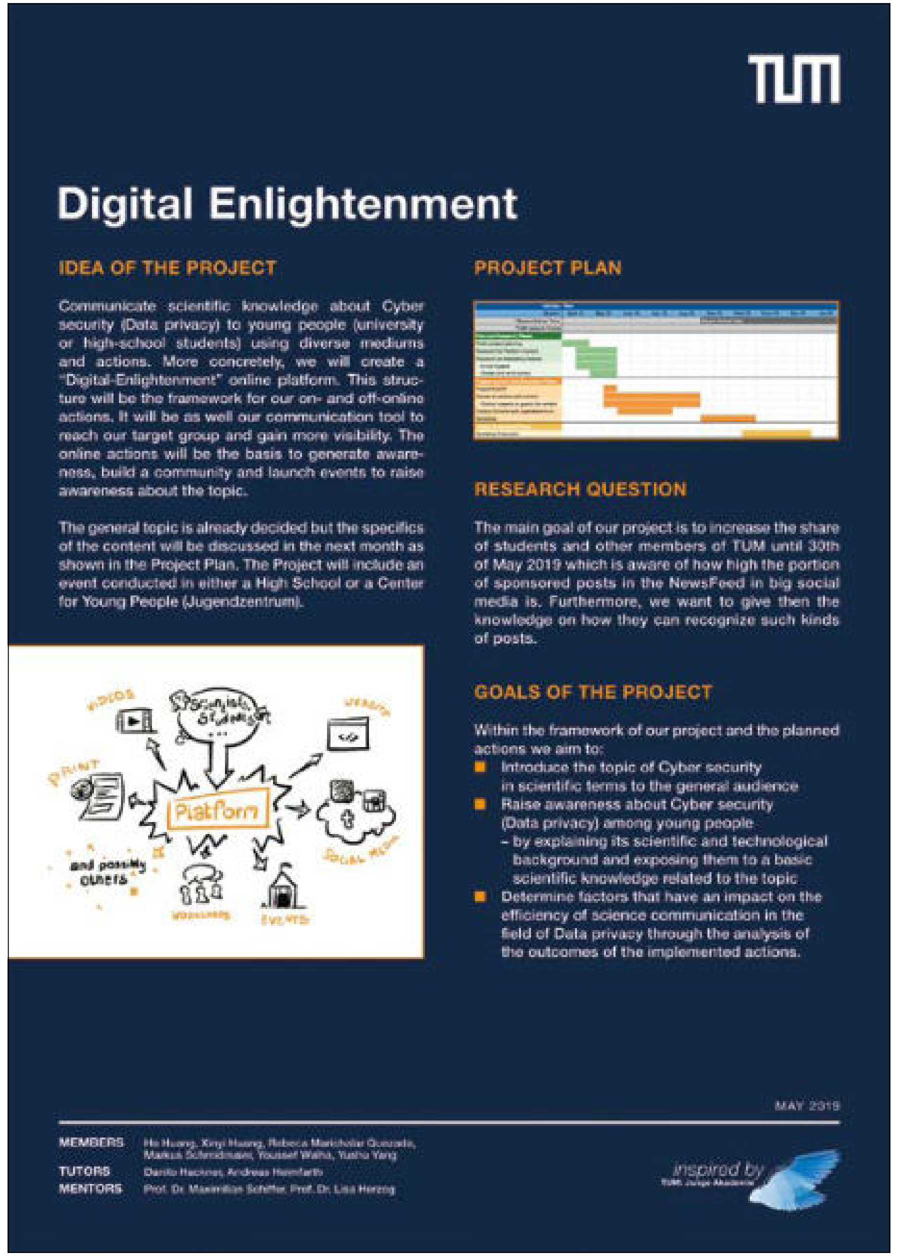
One team member was responsible for the workshop design of a topic. We agreed to deliver exciting and pertinent information through different teaching methods and aids to make the workshop interactive. In our plans, not only did we include audiovisual material, but also interactive forms of teaching such as role-play games, real-time digital interactive games, quizzes, and team competitions. Through several follow-up phone calls and skype discussions, four schools accepted our offer and fixed workshop dates and student numbers with us. However, one of them required german workshops, and no school selected the seminar that one of our teammates had designed. Since the teammate is better as german, we decided to have her hosting the workshop at that school.

In the planning phase, we wanted to have a diffusion campaign distributing posters about our workshops among the participating schools, but many problems arose. Regarding schools, in some cases, it was not possible to get permission to paste our posters ahead of time, or the communication with the schools was not fast enough to make sure we could paste them ahead of the workshop. In terms of the poster design, it was outsourced to a designer. However, the collaboration with him was not optimal: the posters did not meet our initial expectations and had to be redesigned. Besides, our team's busy schedule impeded the posters' collection and mailing. In the end, we tried to make the best out of the situation and decided to bring the final posters to the school and show them during the workshop to draw students' attention towards our workshop.

Fortunately, the workshops were rated as "extremely satisfied" by most students. And we all felt relieved when the workshops were over. However, there was still some room for improvement regarding our team collaboration. Firstly, as a very diverse international team, we were occasionally scattered all over the world. Physical absence in the meeting has impeded the project's advance at the initial stage. Secondly, we started with an ambitious plan but ended up with a relatively small but concrete project. It is a life-long lesson for all of us since it is always necessary to balance our time and interest. Thirdly, like all teams may have encountered, we started to lose our passion in the middle of the project. Therefore, it is worth knowing that resilience sometimes matters the most for a successful project. Fourthly, we stopped our regular meeting since March 2020, when the postpone was announced. This interruption was detrimental to our momentum. It would be better to organize meetings at least once per month (our usual meeting was once per week). Thanks to TUM: Junge Akademie, we as a team has learned how to appreciate every team member's effort and accept imperfections in project's advance; we learned to challenge our limits such as conducting german workshops; we learned that written progress should be as substantial as (or even more important than) simply pushing the project forward. It is an honor for all our members to be a part of TUM: Junge Akademie.

Acknowledgement

Our work would not have been possible without extraordinary support and guidance throughout the whole process from Peter Finger, Maria Hannecker, our supervisors Prof. Dr. Lisa Herzog, Prof. Dr. Maximilian Schiffer, Prof. Dr. Maria Bannert, and our tutors Danilo Hackner and Andreas Heimfarth. We would like to thank Dr.-Ing. Alexander Lang, Dr. Matthias Lehner, and Stefan Röhrl for passing on their experiences and providing suggestions and advice in the project management workshops. We are also grateful for the valuable interview inputs from Prof. Dr. Thomas Neumann, Prof. Georg Sigl, Prof. Dr. -Ing. Klaus Diepold, PD Dr. Marc-Denis Weitze. We would also like to thank the teachers and students at the Kirchseeon Gymnasium, Humboldt-Gymnasium, Gymnasium Phorms Campus München, and Otto-von-Taube Gymnasium for their cooperation and active participation in our workshops. We thank Markus Schmidmaier for his ideas and efforts at the beginning of our project.



Digital Enlightenment

IDEA OF THE PROJECT

Communicate scientific knowledge about Cyber security (Data privacy) to young people (university or high-school students) using diverse mediums and actions. More concretely, we will create a "Digital-Enlightenment" online platform. This structure will be the framework for our on- and off-online actions. It will be as well our communication tool to reach our target group and gain more visibility. The online actions will be the basis to generate awareness, build a community and launch events to raise awareness about the topic.

The general topic is already decided but the specifics of the content will be discussed in the next month as shown in the Project Plan. The Project will include an event conducted in either a High School or a Center for Young People (Jugendzentrum).

PROJECT PLAN

RESEARCH QUESTION

The main goal of our project is to increase the share of students and other members of TUM until 30th of May 2019 which is aware of how high the portion of sponsored posts in the NewsFeed in big social media is. Furthermore, we want to give then the knowledge on how they can recognize such kinds of posts.

GOALS OF THE PROJECT

Within the framework of our project and the planned actions we aim to:

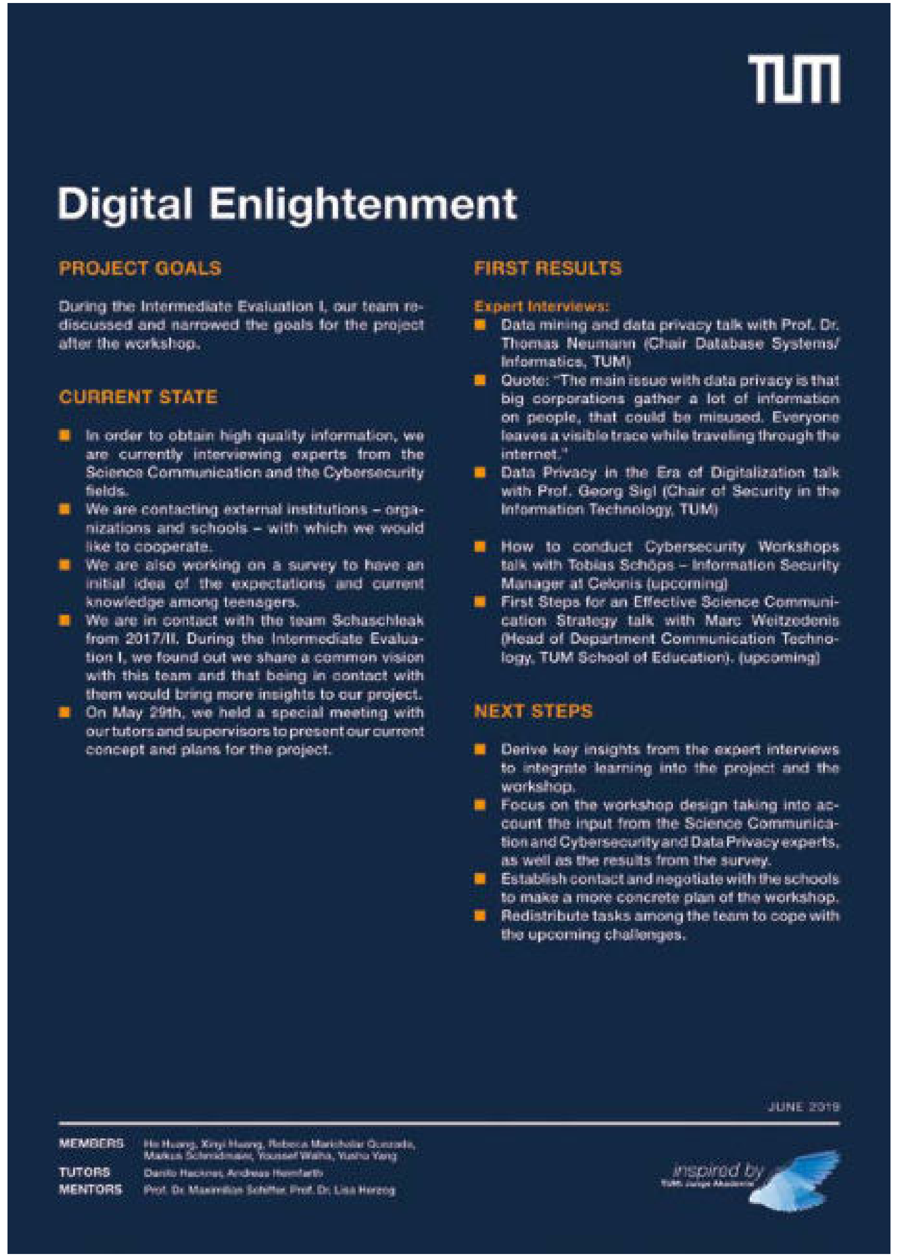
- Introduce the topic of Cyber security in scientific terms to the general audience
- Raise awareness about Cyber security (Data privacy) among young people
  - by explaining its scientific and technological background and exposing them to a basic scientific knowledge related to the topic
- Determine factors that have an impact on the efficiency of science communication in the field of Data privacy through the analysis of the outcomes of the implemented actions.

MAY 2019

MEMBERS Ho Huang, Xinyi Huang, Rebeca Marichalar Quezada, Markus Schmidmaier, Youssef Waha, Yusha Yang
TUTORS Danilo Hackner, Andreas Heimfarth
MENTORS Prof. Dr. Maximilian Schiffer, Prof. Dr. Lisa Herzog

The initial phase of our project was focused on finding a topic that we all found interesting and where we could profit from the interdisciplinary focus of our group. All members contributed to do initial research, identifying topics where major gaps between the scientific community and the public existed. To do this, we consulted Pan-European sources such as public surveys and publications from the European Commission, like the recent reports of the Standard Eurobarometer. We identified several interesting topics where a gap between the public opinion and the academic world exists, such as Food Safety and GM, Population Growth Problems, Energy Resources related to nuclear energy, gas and oil drilling and bioengineered fuels, etc. Finally, the topic of "Cybersecurity and Data Privacy" was the one that called our attention the most, and we chose it as the focus of our project. After that, the project planning began...

POSTER 1: Our first poster reflects the general idea, rough timeline, our scientific research question, and general goals of our project. At this point, we have not fixed our target audience and actions, yet we have already decided on the topic. We were too ambitious at the time and wanted to build an informational platform where both on- and offline actions could be taken to improve the diffusion of our topic from different angles. Our first goals ended up becoming impossible due to the limited duration of the project. In this light, our project plan was modified accordingly and proved to be feasible with minimal delays. The plan and research phase was expected to end by June 2019; the project launch and execution phases were planned to end by November 2019; while the evaluation phase should be finished by early 2020. Though we had to abandon the Evaluation phase due to unexpected issues to distribute post-evaluation surveys among our School Partners during the Coronavirus Crisis, we met all the deadlines for the former stages. In the first poster, our project focused on helping students identify sponsored posts on different social media platforms. That is an entirely different focus from what our real project ended up being. Still, the general goal remained coherent: "to raise awareness about cybersecurity among young people through effective scientific communication." ■



Digital Enlightenment

PROJECT GOALS

During the Intermediate Evaluation I, our team rediscussed and narrowed the goals for the project after the workshop.

CURRENT STATE

- In order to obtain high quality information, we are currently interviewing experts from the Science Communication and the Cybersecurity fields.
- We are contacting external institutions – organizations and schools – with which we would like to cooperate.
- We are also working on a survey to have an initial idea of the expectations and current knowledge among teenagers.
- We are in contact with the team Schaschleak from 2017/II. During the Intermediate Evaluation I, we found out we share a common vision with this team and that being in contact with them would bring more insights to our project.
- On May 29th, we held a special meeting with our tutors and supervisors to present our current concept and plans for the project.

FIRST RESULTS

Expert Interviews:

- Data mining and data privacy talk with Prof. Dr. Thomas Neumann (Chair Database Systems/Informatics, TUM)
- Quote: "The main issue with data privacy is that big corporations gather a lot of information on people, that could be misused. Everyone leaves a visible trace while traveling through the internet."
- Data Privacy in the Era of Digitalization talk with Prof. Georg Sigl (Chair of Security in the Information Technology, TUM)

- How to conduct Cybersecurity Workshops talk with Tobias Schöps – Information Security Manager at Celonis (upcoming)
- First Steps for an Effective Science Communication Strategy talk with Marc Weitzedenis (Head of Department Communication Technology, TUM School of Education). (upcoming)

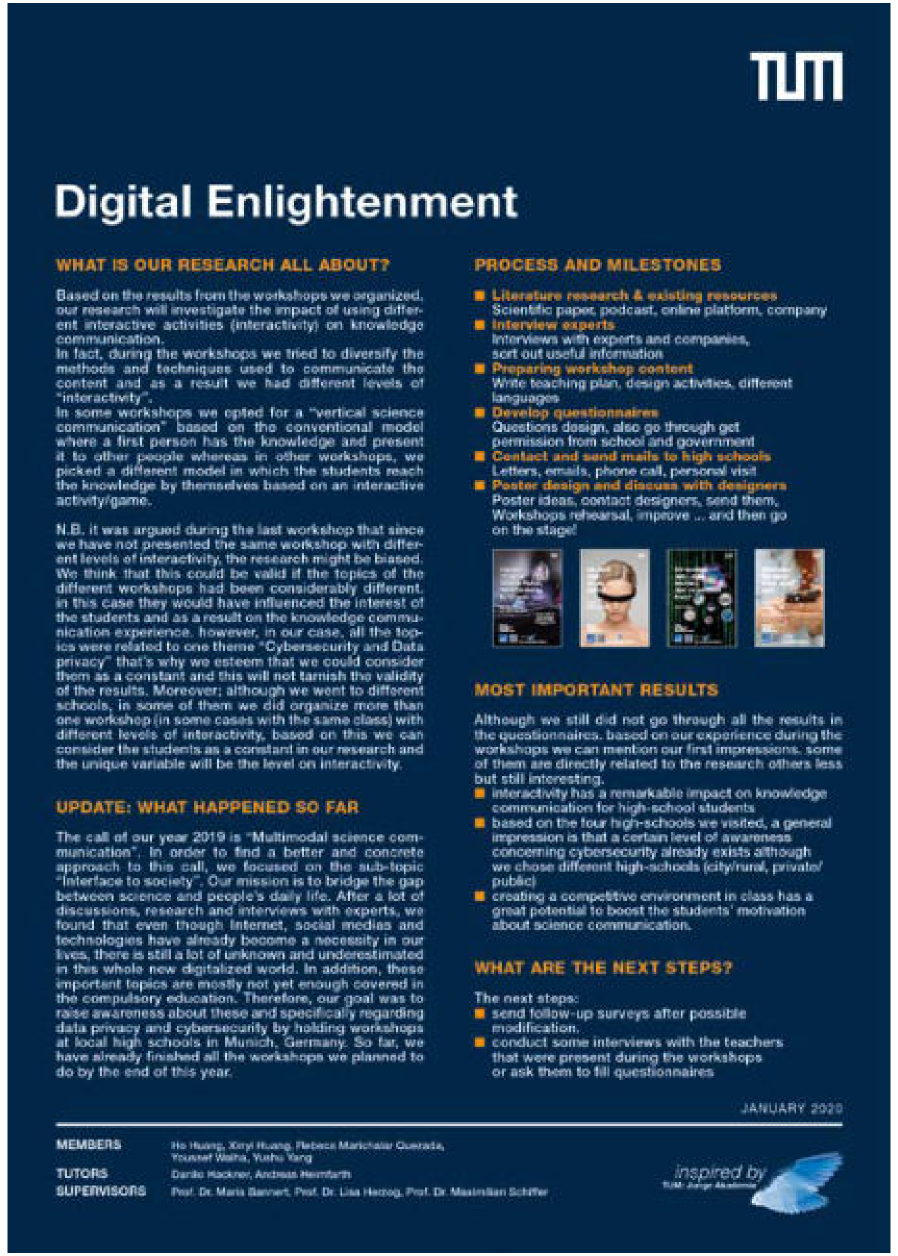
NEXT STEPS

- Derive key insights from the expert interviews to integrate learning into the project and the workshop.
- Focus on the workshop design taking into account the input from the Science Communication and Cybersecurity and Data Privacy experts, as well as the results from the survey.
- Establish contact and negotiate with the schools to make a more concrete plan of the workshop.
- Redistribute tasks among the team to cope with the upcoming challenges.

JUNE 2019

MEMBERS Ho Huang, Xinyi Huang, Rebeca Marichalar Quezada, Markus Schmidmaier, Youssef Waha, Yusha Yang
TUTORS Danilo Hackner, Andreas Heimfarth
MENTORS Prof. Dr. Maximilian Schiffer, Prof. Dr. Lisa Herzog

POSTER 2: At the time of the preparation for the second poster, we were focusing our efforts on becoming experts in "Cybersecurity and Data Privacy." To acquire this expertise, we interviewed several professors at the university and other institutes. By the second poster, we had already talked to three professors at TUM, who inspired us with ideas to narrow the focus of our topic and encouraged us to explore new aspects of it to incorporate it into our project. During the Project Management Training Session in the Intermediate Evaluation I, we managed to narrow our project focus after a long discussion. We decided to choose high school students as our target audience to improve their knowledge of Cybersecurity and Data Privacy, as they are one of the main internet and social media users and usually a vulnerable group target of cyberattacks and Internet malpractice. The plan was to create workshops that we would carry out in different schools in the Munich region. We started by contacting schools during the following weeks to ask for permission to give our workshop. It is worth mentioning that the team Schaschleak from the previous TUMJA batch was of great help. Their research had some common points with ours, and they were very interested in our project and open to collaborating with us. They especially shared valuable learnings on how to create an effective project plan and organizational tips such as how to approach schools. Another important issue at this stage was to design the first concept of our workshop content. The goal of each workshop was to "raise awareness of high school students about cybersecurity and motivate them to more actively protect their online data after the workshop". To this end, we also contacted experts who had previous science communication experiences and learned how to conduct workshops successfully, especially for young people. ■



Digital Enlightenment

WHAT IS OUR RESEARCH ALL ABOUT?

Based on the results from the workshops we organized, our research will investigate the impact of using different interactive activities (interactivity) on knowledge communication.
In fact, during the workshops we tried to diversify the methods and techniques used to communicate the content and as a result we had different levels of "interactivity".
In some workshops we opted for a "vertical science communication" based on the conventional model where a first person has the knowledge and present it to other people whereas in other workshops, we picked a different model in which the students reach the knowledge by themselves based on an interactive activity/game.

N.B. it was argued during the last workshop that since we have not presented the same workshop with different levels of interactivity, the research might be biased. We think that this could be valid if the topics of the different workshops had been considerably different, in this case they would have influenced the interest of the students and as a result on the knowledge communication experience. however, in our case, all the topics were related to one theme "Cybersecurity and Data privacy" that's why we esteem that we could consider them as a constant and this will not tarnish the validity of the results. Moreover; although we went to different schools, in some of them we did organize more than one workshop (in some cases with the same class) with different levels of interactivity, based on this we can consider the students as a constant in our research and the unique variable will be the level on interactivity.

UPDATE: WHAT HAPPENED SO FAR

The call of our year 2019 is "Multimodal science communication". In order to find a better and concrete approach to this call, we focused on the sub-topic "Interface to society". Our mission is to bridge the gap between science and people's daily life. After a lot of discussions, research and interviews with experts, we found that even though Internet, social medias and technologies have already become a necessity in our lives, there is still a lot of unknown and underestimated in this whole new digitalized world. In addition, these important topics are mostly not yet enough covered in the compulsory education. Therefore, our goal was to raise awareness about these and specifically regarding data privacy and cybersecurity by holding workshops at local high schools in Munich, Germany. So far, we have already finished all the workshops we planned to do by the end of this year.

PROCESS AND MILESTONES

- **Literature research & existing resources**
  Scientific paper, podcast, online platform, company
- **Interview experts**
  Interviews with experts and companies, sort out useful information
- **Preparing workshop content**
  Write teaching plan, design activities, different languages
- **Develop questionnaires**
  Questions design, also go through get permission from school and government
- **Contact and send mails to high schools**
  Letters, emails, phone call, personal visit
- **Poster design and discuss with designers**
  Poster ideas, contact designers, send them, Workshops rehearsal, improve ... and then go on the stage!

MOST IMPORTANT RESULTS

Although we still did not go through all the results in the questionnaires. based on our experience during the workshops we can mention our first impressions. some of them are directly related to the research others less but still interesting.

- interactivity has a remarkable impact on knowledge communication for high-school students
- based on the four high-schools we visited, a general impression is that a certain level of awareness concerning cybersecurity already exists although we chose different high-schools (city/rural, private/public)
- creating a competitive environment in class has a great potential to boost the students' motivation about science communication.

WHAT ARE THE NEXT STEPS?

The next steps:

- send follow-up surveys after possible modification.
- conduct some interviews with the teachers that were present during the workshops or ask them to fill questionnaires

JANUARY 2020

MEMBERS Ho Huang, Xinyi Huang, Rebeca Marichalar Quezada, Youssef Walha, Yuzhu Yang
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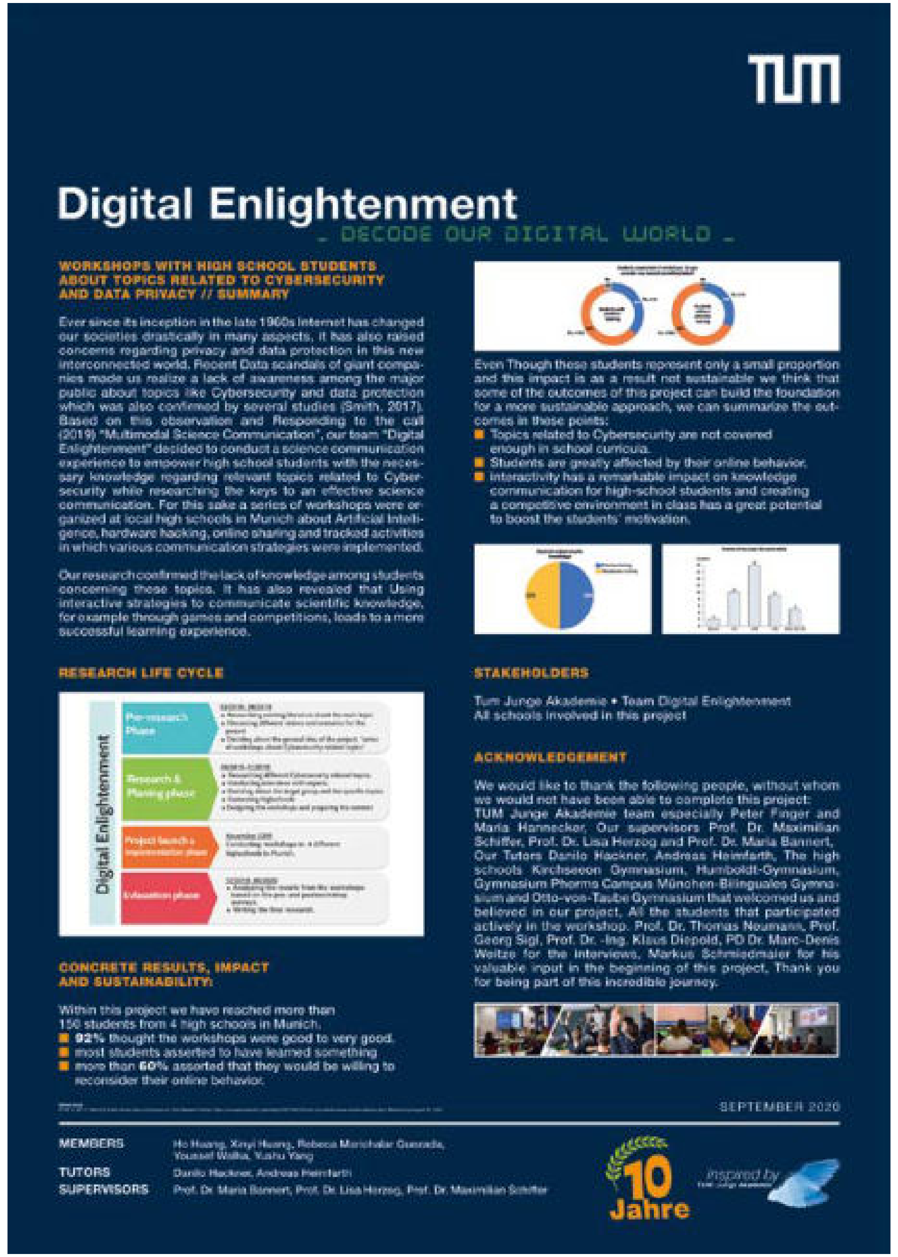
POSTER 3: After intensive research and more interviews with professors and experts from the university and other companies, we started to work on the structure and content of each workshop. We also had already contacted numerous high schools around Munich and proposed our workshop ideas. Eventually, we cooperated with four local high schools – Kirchseeon Gymnasium, Humboldt-Gymnasium, Gymnasium Phorms Campus München, and Otto-von-Taube Gymnasium. We prepared a list of eight sub-topics around our main topic, and the high schools could choose by themselves which of them was the most interesting and appropriate for their students. The most chosen topics were AI, Activity Tracking, Hardware Hacking and Cybersecurity, and Oversharing on Social Media. We prepared all topics with a comprehensive workshop plan template, which were pre-approved by the schools and rehearsed several times before. Our goal was not only to inform the students about different risks on the internet and raise their awareness but also to show how these topics are relevant in real-life. The major goal behind this was to make students more aware of the consequences of their interaction in the digital world and provide them with basic abilities to assess risks on their own and protect themselves. Simultaneously, we wanted to investigate how much did the students know about the topics before the workshops and assess whether an interactive workshop would increase their knowledge on the topic and ultimately result in a change in their online behavior (measured as a willingness to change the behavior). For this, we designed pre and post-workshop questionnaires especially tailored for each topic, and asked the students to fill them out. Although it was not possible to carry out these surveys in all schools for regulatory reasons, we obtained enough data to assess the impact of our workshops. In the end, we received a lot of positive feedback from the teachers and students. This experience also became one of the highlights of our project.


Digital Enlightenment
Pre-research Phase
Research & Planing phase
Project launch & implementation phase
Evaluation phase

Digital Enlightenment

_ DECODE OUR DIGITAL WORLD _

WORKSHOPS WITH HIGH SCHOOL STUDENTS ABOUT TOPICS RELATED TO CYBERSECURITY AND DATA PRIVACY // SUMMARY

Ever since its inception in the late 1960s Internet has changed our societies drastically in many aspects, it has also raised concerns regarding privacy and data protection in this new interconnected world. Recent Data scandals of giant companies made us realize a lack of awareness among the major public about topics like Cybersecurity and data protection which was also confirmed by several studies (Smith, 2017). Based on this observation and Responding to the call (2019) "Multimodal Science Communication", our team "Digital Enlightenment" decided to conduct a science communication experience to empower high school students with the necessary knowledge regarding relevant topics related to Cybersecurity while researching the keys to an effective science communication. For this sake a series of workshops were organized at local high schools in Munich about Artificial Intelligence, hardware hacking, online sharing and tracked activities in which various communication strategies were implemented.

Our research confirmed the lack of knowledge among students concerning these topics. It has also revealed that Using interactive strategies to communicate scientific knowledge, for example through games and competitions, leads to a more successful learning experience.

RESEARCH LIFE CYCLE

CONCRETE RESULTS, IMPACT AND SUSTAINABILITY:

Within this project we have reached more than 150 students from 4 high schools in Munich.

- **92%** thought the workshops were good to very good.
- most students asserted to have learned something
- more than **60%** asserted that they would be willing to reconsider their online behavior.

Even Though these students represent only a small proportion and this impact is as a result not sustainable we think that some of the outcomes of this project can build the foundation for a more sustainable approach, we can summarize the outcomes in these points:

- Topics related to Cybersecurity are not covered enough in school curricula.
- Students are greatly affected by their online behavior.
- Interactivity has a remarkable impact on knowledge communication for high-school students and creating a competitive environment in class has a great potential to boost the students' motivation.

STAKEHOLDERS

Tum Junge Akademie • Team Digital Enlightenment
All schools involved in this project

ACKNOWLEDGEMENT

We would like to thank the following people, without whom we would not have been able to complete this project:
TUM Junge Akademie team especially Peter Finger and Maria Hannecker, Our supervisors Prof. Dr. Maximilian Schiffer, Prof. Dr. Lisa Herzog and Prof. Dr. Maria Bannert, Our Tutors Danilo Hackner, Andreas Heimfarth, The high schools Kirchseeon Gymnasium, Humboldt-Gymnasium, Gymnasium Phorms Campus München-Bilinguales Gymnasium and Otto-von-Taube Gymnasium that welcomed us and believed in our project, All the students that participated actively in the workshop. Prof. Dr. Thomas Neumann, Prof. Georg Sigl, Prof. Dr.-Ing. Klaus Diepold, PD Dr. Marc-Denis Weitze for the interviews, Markus Schmiedmaier for his valuable input in the beginning of this project. Thank you for being part of this incredible journey.

SEPTEMBER 2020

MEMBERS Ho Huang, Xinyi Huang, Rebeca Marichalar Quezada, Youssef Walha, Yuzhu Yang
TUTORS Danilo Hackner, Andreas Heimfarth
SUPERVISORS Prof. Dr. Maria Bannert, Prof. Dr. Lisa Herzog, Prof. Dr. Maximilian Schiffer

POSTER 4: Our project concluded on time at the beginning of 2020. Our final poster summarizes all the work we have done in the last two years. We intended to tell the story of "Digital Enlightenment" by presenting the milestones and the phases of this project. It also gives an insight into the most important results from the evaluation phase. In fact, after conducting the workshops in high schools, we took some time to analyze the data we collected from the surveys. We discussed our impressions and our observations about the outcomes of the workshops and the interaction of the students. That allowed us to draw further conclusions regarding the knowledge of high school students on Cybersecurity topics and the effectiveness of the different science communication strategies we implemented in our workshops (e.g. games, lectures, digital activities, etc.). Certainly, we had to adapt our plans for the Evaluation phase. With the outbreak of the Coronavirus Crisis, it was not possible to send follow-up surveys to schools or to return there for interviews and discussions with the teachers to understand the long-term impact of our workshops as we had planned. Nevertheless, we all were very satisfied with the work done. This last part of the journey was also an occasion to remember how it all started, the challenges, the hardships, the laughs, and especially the people who stood by us and without whom all of this would have never been possible.

Project Report **EvaluaTUM**

Team	Judith Paripovic Pascal Resch Paul Sieber Stefan Engels Stefan Lehner
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Preface by the Supervisor 94
Journalistic part 96
Scientific part 98
Self reflection 110
Posters 112

Preface by the Supervisor

Prof. Dr. Annette Noschka-Roos

There is a magic in every beginning. This well-known quotation from Hermann Hesse always comes to mind in supervising different project teams of the TUM: Junge Akademie (TUMJA). It's characteristic of magical events that they could not be explained in full, but there are some, even essential, ingredients helping to make the magic. First of all the concept of TUMJA has to be mentioned. Choosing and combining students from different domains or faculties brings together different perspectives, different methods for solving problems in an interdisciplinary manner. The students themselves decide on the problems which they want to solve during their two-year projects concerning social issues: projects with subjects like "science goes public" or with health issues within the university or even within the community. This procedure can also be considered an important source of the magic: choosing a problem and starting a project establishes commitment among the students.

In this case the team of the project EvaluaTUM wanted to improve the current evaluation system with a central question in mind: could it be useful to develop the evaluation instrument in such a way that it improves the communication between teachers and learners by direct feedback? And does this help to improve the seminars, lectures and courses, too? Both a simple and a complicated question including tricky and complex issues: different faculties, different domains, different methods for teaching, different personalities on teaching and learning sides, different experiences and many other factors in this multifaceted field.

Choosing the top-down approach for their evaluation project the team of EvaluaTUM convinced two faculties to take part in this project. They developed evaluation instruments in each case with specific questions concerning alternative response times during the lecture, the students participating in the evaluation, the length of the questionnaire, and the basic tools (paper/pencil vs. digital). They were theoretically convinced that these factors, among others, have an impact on the evaluation concerning the feedback quality. Would it have been better to look for examples of best practice using the common instruments for systematically identifying the leading factors for success, a bottom-up analysis? But this would be a time-consuming and methodologically sophisticated approach, so the students used this more suitable one. They worked in an impressive way independently, enthusiastically and with discipline obliged by the fact that some of them were located abroad as guest students. Confronted with a difficult task, the students did a great job. Even though the results cannot be generalized, they are helpful for thinking about previous practice in relation to the current evaluation system. They proved the impact of some factors they had presumed: the length of the evaluation questionnaire, the possibility of answering open questions, the effect of a provided timeframe.

In the end of the evaluation project, another essential ingredient of the magic start is worth mentioning: the dream and the hope of solving an identified problem. It isn't solved but the results show that it was highly worthwhile to consider it seriously. ■

No Excellence without Evaluation

It might seem evident that lectures in general need constant improvement. This also applies to the best lectures. The Technical University of Munich is often said to be excellent – not only in research – but also in teaching. This excellent teaching needs evaluation – constant, outstanding evaluation. Considering all the excellence of TUM, the question might arise why their professors – the smartest and most educated people – need evaluation for teaching?

Obviously, for the last 150 years, professors have been teaching at TUM. Also obvious, not only professors teach at universities. Many lecturers are doctoral students and thus are right at the beginning of their careers. This implies that they still need and want to improve their teaching skills. Although professors are already experienced lecturers and highly educated, there are reasons why a steady evaluation is necessary.

A professor’s job consists mainly of two aspects: research and teaching. Nevertheless most of them see themselves mainly as scientists – not as lecturers – and thus focus more on the former of the two tasks. Therefore training of lecturers is essential.

Unfortunately some lecturers ignore the evaluation process. Luckily they are a minority. Their point of view is: "I am the expert, so I know best what and how to teach." Within this sentence, they ignore several points. Firstly, many students do not comprehend the content as fast as professors. Hence, the students' input is essential. As nobody is perfect, improvement is always possible, especially for teaching students. Perhaps the most important point has nothing to do with the lecturers themselves. Nowadays, everything develops fast. New teaching strategies develop rapidly but not every strategy suits every content of teaching. As students listen to many lectures, they see a lot of different teaching approaches every day. Therefore, they can give valuable feedback. Moreover, not only the methods of teaching change, but also the contents. From this it is evident that even the best lecture concept has to be improved and adapted continuously. Especially, at a so-called excellent university. Therefore it always needs outstanding feedback and evaluation.

Contrariwise, the feedback rates at TUM show that there is still room for improvement in the field of lecture evaluation. The members of team EvaluaTUM tried to tackle this potential in their research. ■

Low Feedback Rates are not the Students’ Fault!

Every semester, lectures at TUM are evaluated. The aim is clear – improvement of the classes. Unfortunately, many lecturers and administrative staff complain about incredibly low feedback rates. They highlight the students’ low motivation and disinterest. But NO. The low feedback rates are NOT the students' fault!

First of all, we – a group of students – need to clarify that none of our colleagues ever refused to give feedback. Whenever lecturers ask how to improve their teaching, they will get the student’s honest opinion about their course. Criticizing bad courses makes a student feel less helpless, hoping that the second half of the semester will get better. Similarly, replying positively to a class means possibly suggesting the lecturer for a teaching award. Motivation from the students’ perspective does exist and is even quite high! Therefore, the low participation must have different reasons. It looks as if the real problem is a structural one!

Also technical issues need to be overcome: Instead of clear and structured processes, online evaluations are sent via email, and students also receive many other emails every day. Sometimes, one mail per evaluation form is required, leading to a huge number of emails in the inbox. Of course, the motivation to click all ten or twelve links is low. One link for every lecture, one link for every exercise, and one link for the labs. These anonymously sent requests for feedback make a student think: “Spend the next two hours with ‘EvaSys’?!” But emails containing the evaluation requests are patient – they can wait. If necessary, forever… NOT on purpose. It just happens because of the inbox’s nature.

If students remember to fill out the survey, they get a bunch of questions with scales from one to five. After half a page, every student starts to tick intuitively. As the questionnaire seems never ending, the second page is ticked with less thought. Attentive students notice that question 29.6 on page 4 is the same as question 2.5. Also the layout – grey and the newest design from the 90s does not help to keep the initial motivation. After the pages of single-choice questions, the students’ motivation is finally gone. The problem is that the last page contains the most helpful part for the lecturer: The open-response questions.

The motivation of the lecturers sometimes seems to be similarly high as the students’ after five pages. As most of the lecturers do not give time for filling out the online questionnaire during the class, it feels like giving feedback is a waste of time. Some do not know the exact evaluation deadline! Additionally lecturers often do not discuss the results. Maybe the results are handed out too late – but motivated lecturers could even discuss the previous year’s results in order to show their interest in improvement.

To conclude, accusing the students for low feedback rates might be a little bit too easy. But in reality, all lecturers can motivate their classes by allocating time for the evaluation itself and reviewing the results together with the students. In addition, the administration could try nicer layouts as well as shorter questionnaires with more focus on free-response questions. To show the influence of these aspects, EvaluaTUM conducted some research. ■

The Influence of Three Different Factors on Lecture Evaluation at TUM

Table of contents:

Abstract

Introduction
  Motivation
  Current System at TUM
  Problem Formulation

Literature Review
  Reliability and Information Value of Evaluations
  Implementation and Response Rate
  Interpretation of Evaluation Results
  Open Feedback Questions

Research Question

Methods
  Evaluation of Needs
  Case Studies
    1. Effect of Provided Time Slot
    2. Impact of the Evaluation Medium
    3. Questionnaire Design

Results
  1. Effect of Provided Time Slot
  2. Impact of the Evaluation Medium
  3. Impact of Question Types

Discussion
  General
    1. Effect of Provided Time Slot
    2. Impact of Evaluation Medium
    3. Questionnaire Design

Conclusion

References

Abstract

To ensure high teaching quality, a good and constantly adapted lecture evaluation is necessary. Technical University of Munich (TUM) has therefore developed a complex evaluation system within the scope of their quality management. Considering the existing system, this report shows that small changes in variables can improve the return rate and feedback quality of lecture evaluations. Analysed independent variables are the time slot given to complete the questionnaires during lectures, the chosen evaluation media (online vs. paper based) and a modification of the questionnaire in terms of length and question type. Therefore, we implement three case studies to validate the following three hypothesis:

1. Giving students time to fill out the questionnaire in the middle of the lecture leads to significantly higher feedback rates compared to not motivating the students during the lecture.
2. Online evaluations increase the return rate in comparison to paper-based evaluation if both are conducted similarly.
3. A shortened evaluation questionnaire with focus on open questions contains more feedback than a questionnaire with focus on single choice questions.

The collected data shows in the first place that the middle of the lecture seems to be the best point of time for maximizing the feedback rate. Secondly, online-based evaluation does not significantly influence the response rates, although more students are reached, i.e. students who do not visit the lecture that specific day can also participate. Thirdly, a shorter questionnaire with focus on open questions improves the feedback quality.

From the latter two points one can derive that small changes in the current lecture evaluation system at the TUM may lead to significantly improved lecture evaluations. Many instances of TUM have already reported their interest to our results in order to improve the evaluation system. One faculty already initiated the rethinking process of their evaluation sheets due to this project.

Introduction

Motivation

Universities are places where research meets higher education and thus lecturers must manage both the scientific research of highly complex contents as well as giving lessons to students. In teaching, they have to consider various aspects: e.g. keeping lectures up-to-date, breaking down complex topics, and being available for their students. To achieve these tasks and to be able to offer an excellent teaching at the university, feedback loops are essential.
Feedback from the students to the lecturer is mostly given by evaluation questionnaires. However, with a high variety of subject areas and lecture types, the range of evaluation means and forms is very wide. There are e.g. classical lectures, practical courses or seminars given by a single or multiple lecturers. When creating and implementing a questionnaire several questions occur:

- Which type of question is optimal for the goal of this questionnaire?
- What is the best ratio between open questions and single-choice questions?
- What is the optimal length of a questionnaire?
- How can one achieve a reasonable return rate?
- How can one ensure a comparability of the lecture feedback?

Besides these uncertainties in the questionnaire development, especially at larger universities, the implementation of general feedback loops is difficult and can be interwoven with the whole system. Due to this high complexity, there is always room for (small) improvements of these feedback-loops. A survey among student representatives at the Technical University of Munich (TUM) confirms improvement potential (Fig. 1). The following report presents the influence of selected levers to increase the feedback quality.

Current System at TUM

At the paper- and online-based questionnaires are typically used including demographic and general questions as well as open questions with room for individual feedback. The evaluation process at TUM consists of three steps. The base is built by the evaluation of courses. Additionally, the degree programs and the entire faculties are evaluated.

To perform the evaluation process, the faculties have responsible employees for quality management. They are supported by the “TUM Center for Study and Teaching - Quality Management, Legal Division and Communications” at university level. A third player within this process is “ProLehre”. They help lecturers to interpret the results and develop plans to improve teaching. Additionally, they perform Teaching Analysis Polls in classes, where the number of students is so low that evaluation forms are not anonymous anymore. [30]

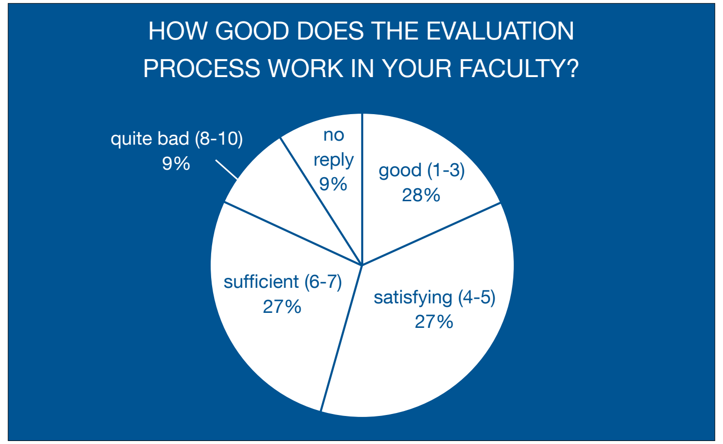


Fig. 1: Response of the students’ representatives of 11 out of 21 different faculties to evaluate the lecture evaluation quality (survey of EvaluaTUM, [7])

The development of the evaluation forms is each faculty’s responsibility. However, there are approximately eight mandatory questions, which each questionnaire must contain. They are important for comparability. The class evaluation takes place either online or paper based with evaluation forms from EvaSys. Some faculties even use a hybrid system. A survey among the student representatives of different faculties shows the high variation of evaluation media used (Fig. 2). Similarly, course evaluations take place at different points of time within the semester, but also within a lecture. The above mentioned survey points out that some faculties evaluate during the lectures, whereas others rely on the students’ evaluation at home (Fig. 3).

In addition to the system at TUM, we were able to experience personally the evaluation systems at Kungliga Tekniska Högskola (KTH) in Stockholm as well as the Eidgenössische Technische Hochschule in Zurich. Derived from all these possible realizations of evaluation and the current implementation at TUM, our main goal of this research is to optimize the evaluation questionnaires at the TUM for better feedback and therefore a further improvement of the teaching.

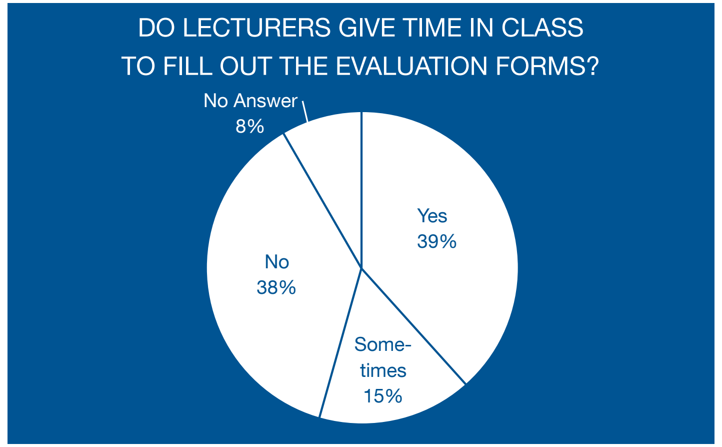


Fig. 2: Response of the students' representatives of 11 out of 21 different faculties to evaluate if the lecturers give time for the evaluation during the lecture (survey of EvaluaTUM, [7])

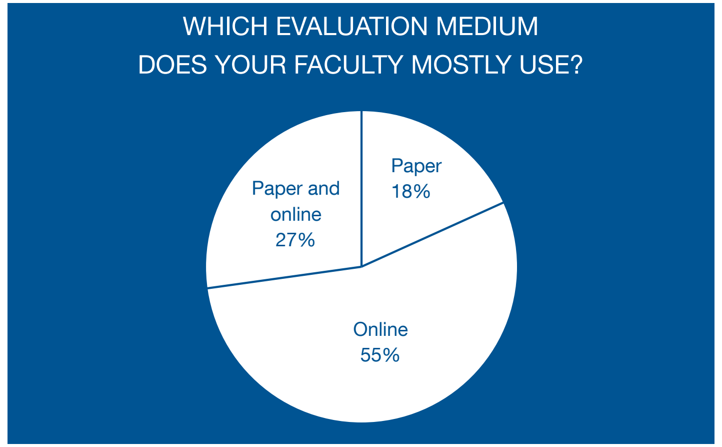


Fig. 3: Response of the students' representatives of 11 out of 21 different faculties to evaluate which medium the faculty uses for the lecture evaluation (survey of EvaluaTUM, [7])

Problem Formulation

To obtain significant evaluation results, a large number of students should participate in an evaluation (Rantanen 2013). In order to increase the occasionally low feedback rates, modifications in the current evaluation method are necessary. Our overall goal can be described as the suggestion of changes, resulting in higher response rates and a more quality feedback outcome in the lecturers' view in order to maintain the full feedback loop. Considering the complexity of the whole lecture evaluation process stated in the first part of the introduction, the leeway for changes is very limited. This leads to the project's research scope: Investigating possible modifications of lecture evaluation within the current system at TUM and specifying their impact.

Literature Review

The following section gives an overview about important results that have been presented in the literature.

Reliability and Information Value of Evaluations

Standardized evaluation questionnaires require a high reliability of the measurement. Even if the participants of an event give different evaluations, the results are stable on average over the survey methods, measurement dates and groups of people [20,24]. As a long-term study (6024 courses, 195 lecturers, 31 courses of study, 13 years) has shown, the results are very stable even if different students evaluate the courses several times over a longer period of time [17,18]. This shows that the evaluations of 74% of the lecturers changed only slightly. Evaluation results are stable even after completion of evaluations. An analysis of 6 individual studies shows that the variances in evaluations by current and former students are identical at about 48% [8]. A further study, in which 100 events were evaluated in a contemporary way and years later, shows a variance of 69% [19].

Implementation and Response Rate

In order to optimize the significance of evaluation results, as many students as possible should participate in an evaluation. About 15 completed evaluation questionnaires are needed to make an evaluation result generalizable [24]. Rinderman and Schofield [25] as well as Kreiter and Lakshman [11] also stated that the evaluation results of about 15 persons are needed to make generalizable statements about the quality of a course. In general, the participation rate in evaluations is far below 100%: according to studies between 30% and 70% of the students that take the class [1,3,6]. This also holds for the TUM, where according to our first study [7], the response rates vary from 3% to 90% among different disciplines and module levels.

Students are more likely to participate in evaluations if they believe that the lecturers will implement the evaluation results in their lectures [4]. As one study shows, an event should be evaluated by only 15 randomly selected participants to make the results more meaningful [11].

The used media (online vs. paper questionnaires) has almost no influence on the evaluation results [6,12,28,30]. At TUM, faculties evaluating with paper seem to have higher response rates than the ones using online evaluation [7].The time of evaluation during the semester also plays only a minor role. Studies show minimal positive effects when an evaluation was carried out in the middle of the semester [5,14].

Interpretation of Evaluation Results

In principle, evaluation results are only guidelines for the lecturers. They also lead to a whole range of emotions of the lecturers (e.g. discouraged, frustrated, angry, motivated, satisfied). Often it is the case that free comments contain hurtful statements [9,15]. Evaluation results do not necessarily lead to an overall improvement of an event. As a study from Germany (3122 evaluation sheets, 12 lecturers, 4 semesters) shows, the quality of a course does not improve despite repeated evaluation [10]. With additional didactic counselling and further education offers, lecturers receive the necessary background knowledge to be able to implement evaluation results accordingly.

Open Feedback Questions

A less frequently used method to design questionnaires is the use of open response questions. For these types of evaluation forms, only little research has been done [2]. Nevertheless, open questions might be an important aspect to design evaluation forms as well as to specify improvement possibilities. This paragraph summarizes the most relevant aspects. The percentage of students responding to open questions varies significantly from 10-70% [2,22]. The length of the responses depends also on the medium: Online questionnaires lead to greater participation in open questions and to longer comments [27]. A higher percentage of comments is generated by short questionnaires [27]. Oliver et al. [22] as well as Zimmaro [31] observe that positive comments prevail in comparison to negative comments. Moreover, positive answers tend to be more general, while negative aspects are rather specific [31]. Although lecturers prefer to interpret individual comments, they are more difficult to interpret [13]. According to Alhija and Fresko [2], the students' answers often comment on the courses' conceptual contents and state specific weaknesses of the course context. This might lead to the assumption that open questions are used for more specific, rather critical feedback which cannot be covered by standardized single-choice questionnaires.

Research Question

As the lecture evaluation system at TUM is interconnected with the accreditation process of the single degrees, the overall structure of the evaluation process is rather strict. Thus, the range of possible modifications are limited and only minor changes can be implemented. To obtain more significant results from evaluation at TUM and to increase the response rate within the given frame at TUM, we will focus on three questions:

1. Does the point of time to fill out the questionnaire in the middle of the lecture lead to significantly higher feedback rates compared to not motivating the students during the lecture?
2. Will online evaluations increase the return rate in comparison to paper-based evaluation if both are conducted similarly?
3. Does a shortened evaluation questionnaire with focus on open questions contain more feedback than a questionnaire with focus on single choice questions?

All three research questions imply rather small changes of the current evaluation system, but will nevertheless provide interesting insights in the complexity of evaluation. Also, these three aspects can be decided by the faculties or the lecturers themselves and therefore do not need big changes.

To answer the questions, the project group carries out three case studies. In the following, the methods and results for the three aspects are presented.

Methods

In this section, the scientific approaches for our research are described. Firstly, we briefly explain how we identify potential in the existing evaluation system. This section is followed by three sections describing the methods used for each research question, respectively.

Evaluation of Needs

In a first step a survey is conducted to find needs within the evaluation system. The questionnaire is sent to the student representatives of all faculties and 11 of 21 faculties participated. It includes questions such as the feedback rate and the medium used for evaluation. Additionally, open feedback is collected. To collect further information, interviews with experts such as quality management officers and lecturers are conducted.

Case Studies

1. Effect of Provided Time Slot

In a first study, the aim is to find if there is a correlation between the feedback rate and whether lecturers give time for evaluation in their lecture. Therefore, 17 lectures in the winter term 2019/2020 at the Munich School of Engineering were investigated. The evaluation takes place within two weeks in december. All students get an email with links to the evaluation of all lectures for which they register.

We split the lectures randomly into three equally large groups. Lecturers of classes in the control group are instructed not to give time during their lectures for evaluation. However, they are allowed to motivate their students to evaluate the lecture from home. In the other groups, the lecturers give approximately 10 minutes within one 90 minute lecture. In the first of these two groups the students get time for evaluation in the middle of the lecture, whilst the other group has time for evaluation at the end of the lecture.

For significance testing, we use the Tukey HSD (honestly significance difference) test. This test compares the mean differences of all pairs. Together with the mean differences, we state the p-values. This test assumes that the means of all pairs are the same. The p-value expresses the probability to see our or more extreme data given that the former assumption is true. A small p-value suggests that this assumption does not hold and the means differ. By convention, a p-value less than 0.05 is said to show a statistically significant difference.

2. Impact of the Evaluation Medium

To compare the impact of the evaluation medium used (online vs. paper based evaluation), we use Welch's t-test. This test compares the means of two different groups of different sizes. It assumes that these means are the same. The p-value expresses the probability to see our or more extreme data given that the former assumption is true. A small p-value suggests that this assumption does not hold and the means differ. By convention, a p-value less than 0.05 is said to show a statistically significant difference.

3. Questionnaire Design

For the third study, we compare an existing questionnaire (shown in figure 04) at the department of chemistry at TUM with a new questionnaire designed by our team (depicted in figure 05) in one lecture with 80 students. The current questionnaire consists of a double sided A4-paper with 36 single-choice questions and about one fourth at the end of the second page were filled with two open text questions. The modified questionnaire is also one double sided questionnaire but except for the first question about the study program, the first page contains only the same two open questions. The second page is composed of 12 single choice questions which are considered as essential for a general evaluation according to TUM guidelines or the faculty of chemistry. This leads to a shortened questionnaire with a distinct focus of open-response questions.

In order to obtain unbiased results we hand out the questionnaire versions alternating the seat rows in the lecture hall. We do not make any announcements regarding the different evaluation sheets beforehand to avoid students recognizing the two versions. Almost no students recognized that there have been two kinds of questionnaires.

Feedback rates depend on the reference participation number. Therefore, we measure it in two ways. Firstly, we compare the number of filled evaluations against the number of students registered for the lecture. As there are students only formally enrolled for a lecture, the ratio of filled forms with registrations for the exams is used as a second measure. Bias arises as some of the students take classes, but write the exam one semester later. Especially modules which run over two or more semesters are a problem. Classes, where this is the case, were not used for the second measure.

One week later, we perform a TAP evaluation to get a ground truth for the feedback which the students wanted to communicate. The TAP is a qualitative method for interim evaluations, during the semester. The TAP is moderated by an external person and the lecturer should leave the lecture hall in order to maintain anonymity. The process can be summarized as follows:

1. **Formation of Groups:** Students are divided into small groups (between 3 and 7 people). Morgan showed, that large group sizes do not contribute to the results [21]
2. **Questioning and Group Discussion:** The moderator poses three questions to the students. The students have 10 minutes to discuss their opinions.
   a. Which aspects of the course do you consider as beneficial for studying?
   b. Which aspects of the course do you consider as an obstacle for studying?
   c. Which suggestions to improve the lecture do you have?
3. **Documentation:** Using key points, the students note their answers. The moderator collects the answers, clarifies ambiguous and misleading statements and reformulates them accordingly. His task is called "Formulating interpretation" [16]
4. **Analysis of the Data:** The moderator determines coding units during the collection of the data. By means of these coding units, the answers are grouped and sorted, after the TAP data collection is completed.
5. **Feedback to the Lecturer:** The first feedback is given by email, promptly after the TAP
6. **Feedback Meeting:** This meeting is conducted according to the "Consultative approach" [23]. The agenda includes the discussion of the lecturers self-reflection and the results of the TAP. The moderator and the lecturer develop together strategies for improvement.

This method has certain advantages: Context-related quality characteristics are captured. Furthermore, the evaluation (TAP) and consultancy is connected. This is very important for effectiveness. Unfortunately, the evaluation results depend on the TAP moderator. Different moderators may weigh opinions subjectively, which results in a non standardized analysis of the answers.

For our research, the procedure is slightly adapted: The students paired in groups and posted their negative and positive aspects on tweedback. The documentation, moderation and data analysis are replaced by "Likes" on tweedback, indicating the relevance of each aspect. This leads to a list of negative and positive aspects as well as improvement suggestions, ranked by importance.

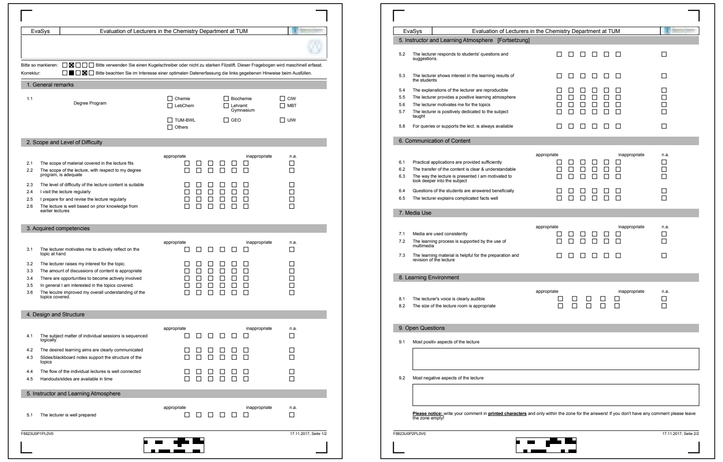


Fig. 4: Current questionnaire for lecture evaluation at the faculty of chemistry at TUM

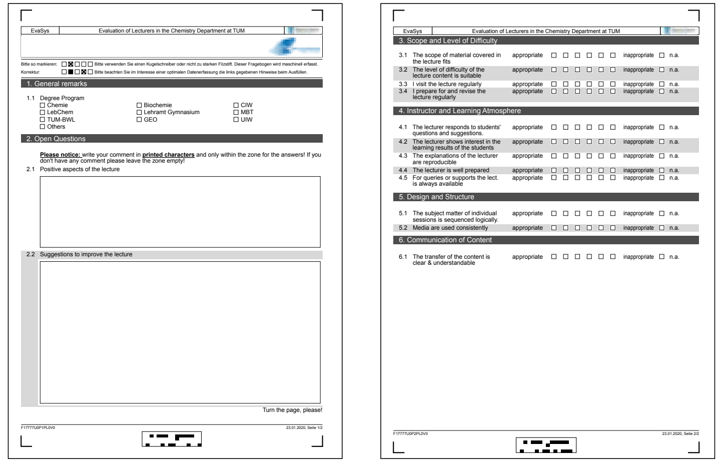


Fig. 5: Modified questionnaire for lecture evaluation with fewer questions and focus on open questions

Results

In this section, we present the results for all three case studies. We begin with the effect between paper- and online-based evaluation in general to see if the medium used has a significant impact on the number of participants. Secondly, we compare the different groups within online evaluation to assess how the response rate can be maximized. As a third part, the quality of answers received from two different questionnaires are compared.

First, for the former two studies, we removed two outliers from our data set. Due to very few exam registration, the corresponding response rates exceeded 100% and therefore do not provide a meaningful measure. Thus, a total of 15 lectures have been analyzed. In 4 lectures no time was given to fill out the questionnaire. 5 Lectures provided time around the middle of the lecture and 6 lectures at the end of the lecture. We also collected corresponding numbers of paper evaluation the preceding year.

1. Effect of Provided Time Slot

The provided time for filling out the evaluation questionnaire varies strongly at TUM. We analyze how the different ways of performing online evaluation affect the response rate. The boxplots in Fig. 6 and Fig. 7 present the different response rates measured with respect to lecture registrations and exam registrations respectively. The color and x-axis show the group (no time provided, time provided around the middle of the lecture, time provided at the end of the lecture), whereas the y-axis depicts the corresponding response rate. As described in Methods, we use Tukey's HSD test for significance testing.

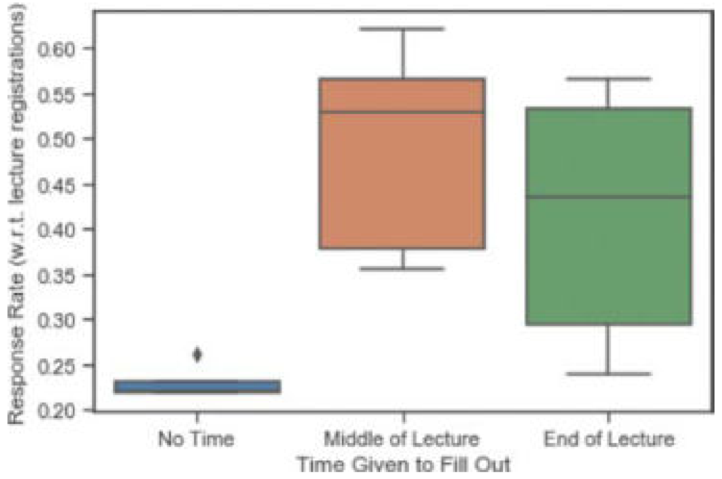


Fig. 6: Response rate with respect to lecture registrations of the investigated lectures, grouped by the time provided to answer the questionnaire

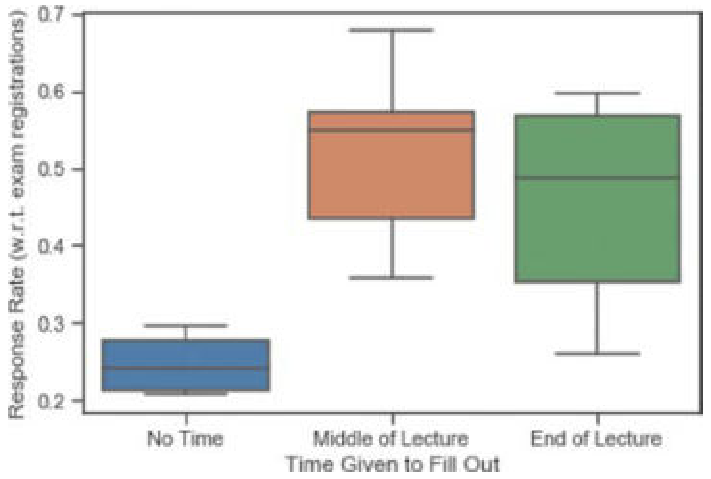


Fig. 7: Response rate with respect to exam registrations of the investigated lectures, grouped by the time provided to answer the questionnaire

If the response rate is measured with respect to lecture registrations, we find that significantly more students fill out the questionnaire when time is given in the middle of the lecture compared to none (p-value 0.014). On average, the response rate was increased by 26 percentage points. With a p-value of 0.068 we have strong reasons to believe that similar conclusions can also be made for time provided at the end of a lecture, however still not being significant at 0.05 level. We can also identify a small trend suggesting that providing time in the middle of the lecture might be better than in the end. These findings presented in table 1 are, however, only small and not statistically significant for the provided sample size.

The same conclusions can also be drawn if exam registrations are taken as a basis for calculating the response rate (Table 2). In this case both time in the middle and at the end significantly increase response rate at significance level 0.05. Thus, our findings are independent of the two used definitions of response rate.

Finally, we can conclude that in order to receive feedback from most students during an online evaluation, each lecturer should provide time around the middle of the lecture for the students to fill out the questionnaires. On average the response rate increases by more than 25 percentage points with a 95% confidence interval between 5 and 48 percentage points.

	Mean Difference of Response Rates	p-value	Interpretation
Middle of Lecture vs. End of Lecture	-0.076	0.536	Not significant
No Time vs. Middle of Lecture	0.260	0.014	Time provided around the middle of the lecture significantly increases response rates compared to not providing time at all
No Time vs. End of Lecture	0.184	0.068	Not significant

Table 1: Results of the case study investigating the effect of provided time slot, based on response rates with respect to lecture registrations

	Mean Difference of Response Rates	p-value	Interpretation
Middle of Lecture vs. End of Lecture	-0.063	0.655	Not significant
No Time vs. Middle of Lecture	0.271	0.013	Time provided around the middle of the lecture significantly increases response rates compared to not providing time at all
No Time vs. End of Lecture	0.208	0.045	Time provided at the end of the lecture significantly increases response rates compared to not providing time at all

Table 2: Results of the case study investigating the effect of provided time slot, based on response rates with respect to exam registrations

2. Impact of the Evaluation Medium

Using the collected data, we assess if online evaluation gives a higher feedback rate than paper based evaluation. The summarized data is shown in table 3. Paper based evaluation was conducted in winter semester 2018/19 and online based evaluation in winter semester 2019/20.

It seems more comparable to use the online evaluation "with time" as comparison. While it is unknown at which times during the lectures paper based evaluation was conducted, it is generally hard to do a paper based evaluation outside the lecture. In this case an online based evaluation increased the mean response rate by 9 percentage points. With p values of 0,20 (w.r.t. lecture registration)

Group	Response Rate w.r.t. Lecture Registrations	Response Rate w.r.t. Exam Registration
Paper based evaluation	35.4%	39.9%
Online based evaluation	39.1%	42.1%
- No time provided	23.0%	24.7%
- With time provided (at the middle or end of lecture)	44.9%	48.4%

Table 3: Results of the case study investigating the impact of the evaluation medium

and 0,26 (w.r.t. exam registration) this difference is not statistically significant.

If, however, the lecturer does not provide a time slot during the lecture, response rates drop by 12 (p value: 0.05) and 15 percentage points (p value: 0.04) respectively. Those findings are statistically significant. However, as argued, this is less meaningful since both provided time and medium are changed.

All in all it seems that an online based evaluation conducted under similar circumstances increases the response rate slightly, but not significantly. The hypothesis of declining number of responses could only be proven if no time was offered to fill out the questionnaire during lectures.

3. Impact of Question Types

In this section, we compare our results that have been conducted at the faculty of chemistry. As mentioned above, we will qualitatively compare two versions of an evaluation questionnaire with the performed Teaching Analysis Poll (TAP) and highlight the most important results: The current form focuses on single choice questions, while the modified form is shortened and focuses on open questions.

Firstly, we compare the replies from the open questions of the two questionnaires. It is noteworthy that the overall amount of answers to open questions has tripled from the current (29%) to the modified questionnaire (79%). Moreover, the respondents used about 2.5 times more words in the modified survey in comparison to the current questionnaire. Not only did the participants write longer and more answers; it should also be noted that the number of presented positive arguments has nearly tripled.

Subsequently, we present the results of the single and multiple-choice questions. Overall, we discover that the results of both questionnaires regarding the single choice questions are relatively similar, even though the current survey has its focus on single choice questions and the modified questionnaire has considerably less questions of this type. For example, a question regarding “The lecturer shows interest in the learning success of his students” has been graded in both questionnaires with an average of 1.6. Furthermore, one question regarding the “Interesting contents” was graded with an average of 1.6 in the modified survey. The questions regarding this context in the current questionnaire were marked with an average of 1.8 (“Interesting topics”), 1.4 (“Interest of the student”), 2.3 (“suitable contents”).

Finally, the results of TAP are compared with the two questionnaires. Altogether, it can be said that answers to the open questions in the modified questionnaire are much more comprehensive than the answers in the current version.

Discussion

General

As each case study was only conducted at one single faculty, the sample size is small. If needed, our findings should be confirmed using a larger sample size and including multiple faculties.

1. Effect of Provided Time Slot

As expected, our study shows that providing time within the lecture to fill out the evaluation form influences the feedback rate positively. This is also underlined by the response rates expected by [1,3,6]: The response rates with no time slot for evaluation provided fall remarkably below the average values of 30-70%, while the response rates with time provided fall in this range.

Although the case study was explained to the lecturers and even though we were in contact with lecturers and students, it is not entirely sure if the time slot for evaluation was provided as described. To increase the results’ accuracy, we check the timestamp of every lecture. To give an example, in one lecture, that was assigned to provide time in the middle of the lecture, we observe a large number of timestamps towards the end of a lecture. Asking students who visited this lecture, confirmed that the time was provided towards the end of the lecture and the group is thus changed. Results like this add bias to our study.

2. Impact of Evaluation Medium

The response rates with respect to exam registrations as well as those with respect to lecture registrations lie in the lower range expected in the literature [1,3,6]. Despite this fact, the results seem reasonable considering the high tendency of TUM students to register for exams and lectures without attendance intention.

It is not recorded at which time during the lecture the paper based evaluation was conducted, whereas we collected this data for online based evaluation. We can thus not perfectly control for this variable when comparing paper based with online evaluation. Since we are not able to find a significant difference between those time points, we assume that our results would only slightly change. Nevertheless, this should be done in further research to receive clearer results. Additionally, data for paper based and online evaluation comes from different years, which is another uncontrolled variable in our study. We could not show a significant difference between the evaluation medium used. This is in line with the results of many other studies [6,12,28,30].

3. Questionnaire Design

Our study suggests that shorter questionnaires lead to more high quality open response feedback (increasing from 29% of the students responding to open feedback questions to 79%), which was also suggested by Sorenson & Reiner [27]. The response rates from the current questionnaire can be classified as at the lower edge of the literatures’ estimates [2,22], while those from the modified questionnaire lie on the upper edge.

It should be noted that some questions from the current survey have not been asked in the modified questionnaire. This leads to problems concerning the qualitative comparison of the two questionnaire versions: Negative questions in the current questionnaire, which are not part of the modified version, might not be mentioned by the students’ responses in the modified questionnaire. Additionally, the given single choice questions might influence the students’ thinking. Another disadvantage of the shortened questionnaire is that the actual number of students supporting an aspect is not known if this aspect appears only in the open questions.

Conclusion

Evaluating lectures is a complex topic, especially if the evaluation is interconnected with a broad quality management system as at TUM. Although having already obtained a well-elaborated evaluation system at TUM, our study suggests that small changes can significantly improve the evaluation system even further:

1. A lecturer should provide time within the lecture for the students to fill out the questionnaire. By doing so, the number of feedback received can be significantly increased by approximately 25 percentage points. Our study suggests that providing time around the middle of the lecture might slightly increase the response rate compared to the end of the lecture. This trend is however not statistically significant.
2. The medium of evaluation (paper vs. online) does not significantly change the response rates, even though more students are reached – including those not attending the lecture regularly.
3. The results of differently designed questionnaires suggest to drastically shorten the single choice questions in favor of more high quality feedback received through open response questions. The shortening of single choice questions does not lead to remarkably decreased feedback interpretation possibilities. Answers to the open questions increased by 150% and contain more positive and longer aspects. Similarly, the comments are much more comprehensive in the modified questionnaire.

To conclude, hypotheses 1 and 3 are confirmed, whereas hypothesis 2 is neither confirmed nor rejected. Further research is needed to strengthen our results: It would be helpful to repeat the conducted studies with more lectures from different faculties. Also different forms of teaching, such as seminars and laboratories, should be added.

Regarding the currently growing online lectures, the results of the case studies investigating the effect of provided time slots and the impact of question types are still valid. Also for online lectures via Zoom or a similar tool, providing time will increase the response rate and open questions will lead to more detailed feedback.

It would also be interesting to assess other methods of increasing the focus on open response questions. Kungliga tekniska högskolan (KTH) in Stockholm for example furnishes every single choice question with a small text field, where a student can comment on the answer he or she has given to the single choice question. This has the advantage that these answers are directly put into context. The effect on feedback quality is unknown as of now, but could be evaluated in a follow up study. More research could investigate the influence of course evaluation after examinations, or publishing regularly the evaluation results of all classes. Both aspects are considered at ETH Zürich and might show a Best-Practice example. ■

References

1. Adams MJD, Umbach PD (2012) Nonresponse and Online Student Evaluations of Teaching: Understanding the Influence of Salience, Fatigue, and Academic Environments. Res High Educ 53: 576–591. https://doi.org/10.1007/s11162-011-9240-5
2. Alhija FN-A, Fresko B (2009) Student evaluation of instruction: What can be learned from students' written comments? Studies in Educational Evaluation 35: 37–44. https://doi.org/10.1016/j.stueduc.2009.01.002
3. Arnold IJM (2009) Do examinations influence student evaluations? International Journal of Educational Research 48: 215–224. https://doi.org/10.1016/j.ijer.2009.10.001
4. CHEN Y, HOSHOWER LB (2003) Student Evaluation of Teaching Effectiveness: An assessment of student perception and motivation. Assessment & Evaluation in Higher Education 28: 71–88. https://doi.org/10.1080/02602930301683
5. Cohen PA (1981) Student Ratings of Instruction and Student Achievement: A Meta-analysis of Multisection Validity Studies. Review of Educational Research 51: 281–309. https://doi.org/10.3102/00346543051003281
6. Dommeyer CJ, Baum P, Hanna RW et al. (2004) Gathering faculty teaching evaluations by in class and online surveys: their effects on response rates and evaluations. Assessment & Evaluation in Higher Education 29: 611–623. https://doi.org/10.1080/02602930410001689171
7. Engels S, Lehner S, Paripovic J et al. Projects in Prospect 2019: EvaluaTUM. In: President of TUM, Prof. Dr. Dr. h.c. mult. Wolfgang A. Herrmann (ed) Research Reports, 2017/II, pp 144–145
8. Feldman KA (1989) The association between student ratings of specific instructional dimensions and student achievement: Refining and extending the synthesis of data from multisection validity studies. Res High Educ 30: 583–645. https://doi.org/10.1007/BF00992392
9. Gray M, Bergmann BR (2003) Student Teaching Evaluations: Inaccurate, Demeaning, Misused. Academe 89: 44–46
10. Kersting M, Lang JWB Langfristige Effekte von regelmäßigem Feedback aus studentischen Lehrveranstaltungsevaluationen. Lehrstuhl und Institut für PsychologieUR - http://publications.rwth-aachen.de/record/89645
11. Kreiter CD, Lakshman V (2005) Investigating the use of sampling for maximising the efficiency of student-generated faculty teaching evaluations. Med Educ 39: 171–175. https://doi.org/10.1111/j.1365-2929.2004.02066.x
12. Leung DYP, Kember D (2005) Comparability of Data Gathered from Evaluation Questionnaires on Paper and Through the Internet. Res High Educ 46: 571–591. https://doi.org/10.1007/s11162-005-3365-3
13. Lewis KG (2001) Making Sense of Student Written Comments. New Directions for Teaching and Learning 2001: 25. https://doi.org/10.1002/tl.25
14. L'Hommedieu R, Menges RJ, Brinko KT (1990) Methodological explanations for the modest effects of feedback from student ratings. Journal of Educational Psychology 82: 232–241. https://doi.org/10.1037/0022-0663.82.2.232
15. Lindahl MW, Unger ML (2010) Cruelty in Student Teaching Evaluations. College Teaching 58: 71–76. https://doi.org/10.1080/87567550903253643
16. Loos P, Schäffer B (2001) Das Gruppendiskussionsverfahren: Theoretische Grundlagen und empirische Anwendung. Qualitative Sozialforschung, vol 5. VS Verlag für Sozialwissenschaften, Wiesbaden
17. Marsh HW, Hocevar D (1991) Students' evaluations of teaching effectiveness: The stability of mean ratings of the same teachers over a 13-year period. Teaching and Teacher Education 7: 303–314. https://doi.org/10.1016/0742-051X(91)90001-6
18. Marsh HW, Hocevar D (1991) The multidimensionality of students' evaluations of teaching effectiveness: The generality of factor structures across academic discipline, instructor level, and course level. Teaching and Teacher Education 7: 9–18. https://doi.org/10.1016/0742-051X(91)90054-S
19. Marsh HW, Overall JU (1980) Validity of students' evaluations of teaching effectiveness: Cognitive and affective criteria. Journal of Educational Psychology 72: 468–475. https://doi.org/10.1037/0022-0663.72.4.468
20. Marsh HW, Roche LA (1997) Making students' evaluations of teaching effectiveness effective: The critical issues of validity, bias, and utility. American Psychologist 52: 1187–1197. https://doi.org/10.1037/0003-066X.52.11.1187
21. Morgan DL (2009) Focus groups as qualitative research, 2. ed.,. Qualitative research methods series, vol 16. Sage Publ, Thousand Oaks, Calif.
22. Oliver B, Tucker B, Pegden (2007) An investigation into studentcomment behaviors: Who comments, what do they say, and do anonymous st udentsbehave badly? In: Coates H (ed) Developing generalisable measures of knowledge and skill outcomes in higher education. Australian Universities Quality Agency
23. Penny AR, Coe R (2004) Effectiveness of Consultation on Student Ratings Feedback: A Meta-Analysis. Review of Educational Research 74: 215–253. https://doi.org/10.3102/00346543074002215
24. Rantanen P (2013) The number of feedbacks needed for reliable evaluation. A multilevel analysis of the reliability, stability and generalisability of students' evaluation of teaching. Assessment & Evaluation in Higher Education 38: 224–239. https://doi.org/10.1080/02602938.2011.625471
25. Rindermann H, Schofield N (2001) Generalizability of Multidimensional Student Ratings of University Instruction Across Courses and Teachers. Research in Higher Education 42: 377–399. https://doi.org/10.1023/A:1011050724796
26. Schneider M, Mustafić M (2015) Gute Hochschullehre: Eine evidenzbasierte Orientierungshilfe. Springer Berlin Heidelberg, Berlin, Heidelberg
27. Sörenson DL, Reiner C (2003) Charting the Uncharted Seas of Online Student Ratings of Instruction. New Directions for Teaching and Learning 96: 1–24
28. Stowell JR, Addison WE, Smith JL (2012) Comparison of online and classroom-based student evaluations of instruction. Assessment & Evaluation in Higher Education 37: 465–473. https://doi.org/10.1080/02602938.2010.545869
29. TUM Center for Study and Teaching, Studium und Lehre – Qualitätsmanagement QM-Handbuch zum Studiengangslebenszyklus: Prozesse, Wegweiser und Vorlagen. http://www.lehren.tum.de/?id=422#c6260. Accessed 17 Jul 2020
30. Venette S, Sellnow D, McIntyre K (2010) Charting new territory: assessing the online frontier of student ratings of instruction. Assessment & Evaluation in Higher Education 35: 97–111. https://doi.org/10.1080/02602930802618336
31. Zimmaro DM, Gaede CS, Heikes EJ et al. Running Head: Study of Written Course Evaluation Comments

Self Reflection

From the very beginning, our team had a clear vision: All of us wanted to improve the evaluation system at the Technical University of Munich (TUM). Therefore, we could focus directly on the project and had not to search for a concrete goal. Due to our small team size of five members this was very efficient.

However, we had difficulties in the beginning. Two of us were in Zurich for the first 9 months. We could thus not meet in person, which led to less personal contact. Also our supervisor and tutors were not named before January. However, until the end of January, we already prepared our team structure, which we had to adjust later on.

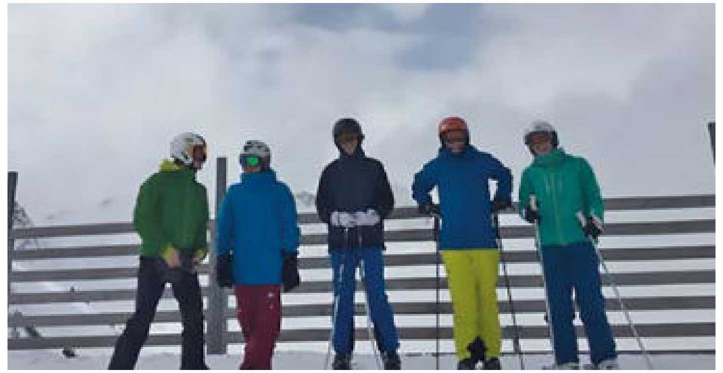
After the kickoff event, our project plan was to do literature review and get in contact with TUM administration. In the following we wanted to structure our ideas, derive a hypothesis and plan our methodology. These methods should have been discussed with different faculties and then be implemented. The final step was to evaluate our data gained and write the report.

The literature research turned out to be a difficult start. As none of us had insights and knowledge in the field of evaluation, the correct keywords to find useful references were missing. Only looking up for the buzzword "evaluation" results in literature about evaluation of industrial processes and economical services. None of us knew how we could get deeper into the material. As we also did not have a supervisor at this part of the project, we kept our literature review very superficial. This might have been a problem that slowed us down.

While communicating with different people from TUM we learned many lessons. However, these were not only things, which helped us with our project. In many cases, we learned about communication and miscommunication. We learned about difficulties contacting people via email and about problems meeting people in person. We figured out that communication could make people think that there are problems, while there are actually none. All these issues made us learn a lot, but threw us also back regarding our schedule. Due to conflicts resulting from (mis)communication, our project partners had not yet been available. Therefore, we developed ideas without partners first and searched for partners later on. This plan had its advantages but also disadvantages. As we already had clear concepts, we were able to present our prospective partners a clear view over possible implementations of our ideas. However, we had to develop more concepts, to be adaptive for our partners. This also led to the point that not necessarily our favourite models were implemented.

Before we were able to present the concepts to prospective partners, we had to develop them. Somehow harder than gaining ideas, was to specify the most useful and reasonable ones. Therefore, we created a document and rated all ideas by different factors. This was on the one hand a fast and efficient possibility. On the other hand, it was a partly random procedure. To overcome this, we planned some expert interviews to rate our ideas. Therefore, we had to find different people who are involved in teaching (e.g. lecturers, quality managers, students). As we were already quite late in our process, we skipped this part, which we should have done earlier.

The implementation phase began during the summer break. This worked out better than expected, even if there were usually three of the five of us on holiday. The issue was more after the summer holidays: It was hard to motivate ourselves and our structures did not help us. Unfortunately, our supervisor was not available for three months. In this time, our tutor helped us a lot to restructure ourselves and we developed again at a faster pace. One change we made was to name two members responsible for each case study with the Faculty of Chemistry and the Munich School of Engineering. They were each responsible for the overview and coordination of the team members. This was a well-timed change at the right moment. However, also not being too strict in earlier stages helped us that all worked together.

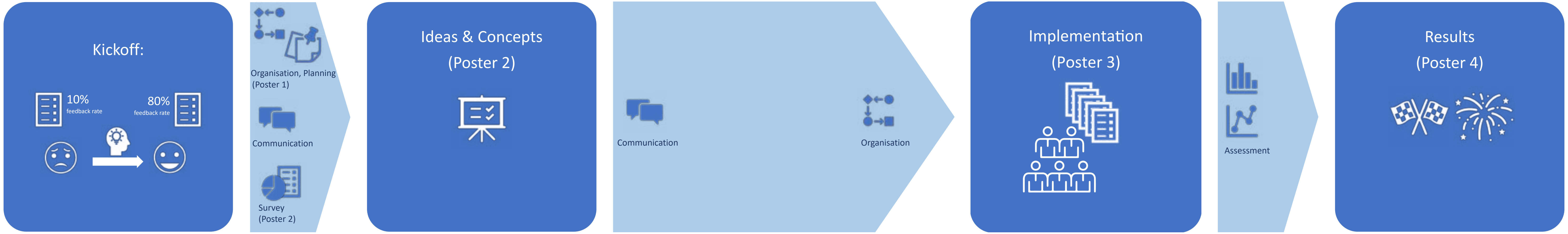


In November, the main part of our implementations started. Even though some minor problems occurred, our clear target helped us to overcome these issues. In this phase of our project, we had an intense exchange with our tutor to get everything done as good as possible. However, we noticed that our motivation decreased for our second implementation. Beside the fact that we already had done one project part and were less motivated to overcome more unexpected difficulties, also the exam period made team members less involved.

Looking at the whole project, it was difficult for us to find established concepts to measure the outcome of our experiments. To find the final chosen measurement, we had two main steps. The first one was the statistical consulting offered by the TUM. This helped us a lot to interpret the quantitative results correctly. On the other hand, we also wanted to make a qualitative analysis. Therefore, we searched for expert knowledge and got in touch with Mrs. Spiekermann and ProLehre, a TUM institution. They gave us an idea how to get a benchmark and also trained us for that.

As during the whole project phase, always at least one of our team members was abroad, the TUM: Junge Akademie supported us by a weekend trip to our members abroad. We met in Zurich and developed our project ideas. A second meeting was planned in Stockholm, but got cancelled due to the corona pandemic. Beside the TUM: Junge Akademie weekend meetings, our only team meeting in person over the whole 20 months period, remained the weekend in Zurich. ■

Process Description



Kickoff:

10% feedback rate

80% feedback rate

Organisation, Planning (Poster 1)

Communication

Survey (Poster 2)

Ideas & Concepts (Poster 2)

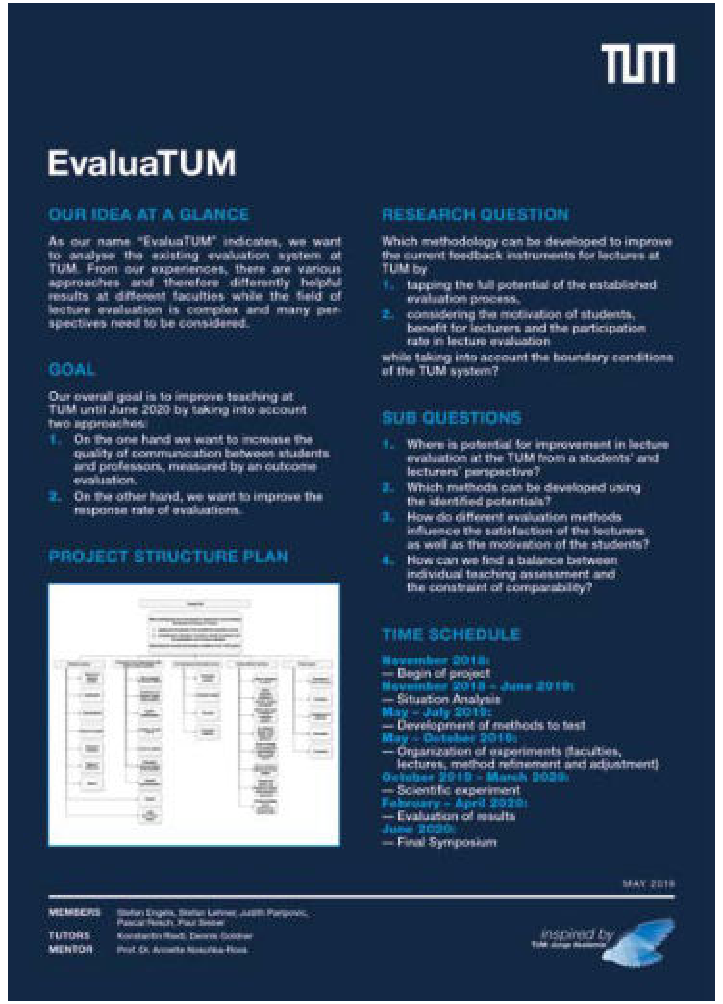
Communication

Organisation

Implementation (Poster 3)

Assessment

Results (Poster 4)



EvaluaTUM

OUR IDEA AT A GLANCE

As our name "EvaluaTUM" indicates, we want to analyse the existing evaluation system at TUM. From our experiences, there are various approaches and therefore differently helpful results at different faculties while the field of lecture evaluation is complex and many perspectives need to be considered.

GOAL

Our overall goal is to improve teaching at TUM until June 2020 by taking into account two approaches:

1. On the one hand we want to increase the quality of communication between students and professors, measured by an outcome evaluation.
2. On the other hand, we want to improve the response rate of evaluations.

PROJECT STRUCTURE PLAN

RESEARCH QUESTION

Which methodology can be developed to improve the current feedback instruments for lectures at TUM by

1. tapping the full potential of the established evaluation process,
2. considering the motivation of students, benefit for lecturers and the participation rate in lecture evaluation

while taking into account the boundary conditions of the TUM system?

SUB QUESTIONS

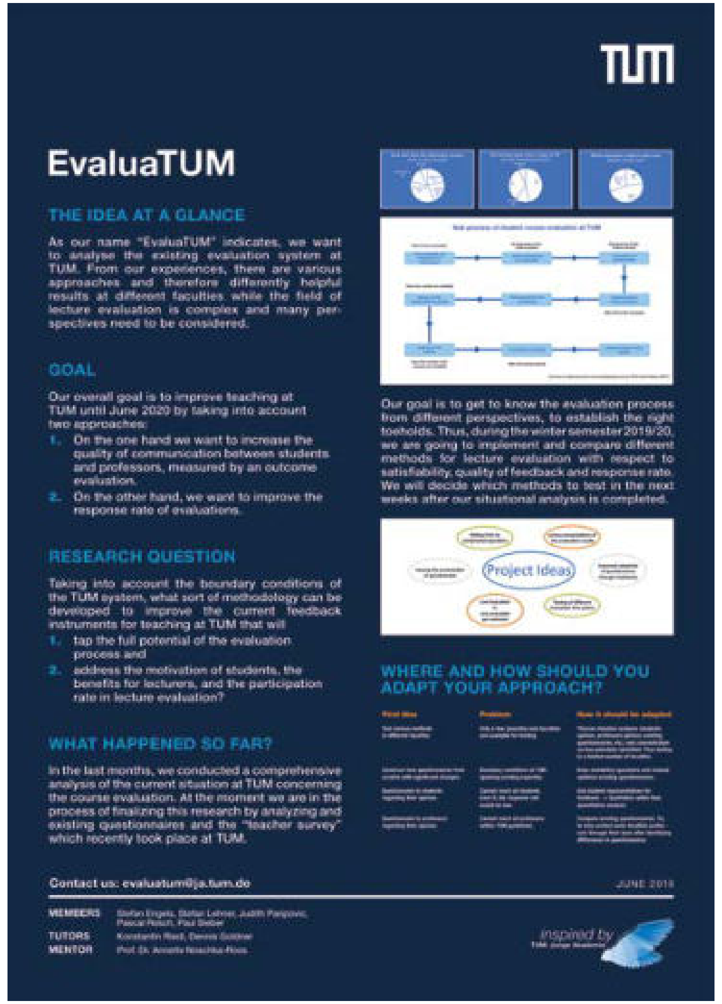
1. Where is potential for improvement in lecture evaluation at the TUM from a students' and lecturers' perspective?
2. Which methods can be developed using the identified potentials?
3. How do different evaluation methods influence the satisfaction of the lecturers as well as the motivation of the students?
4. How can we find a balance between individual teaching assessment and the constraint of comparability?

TIME SCHEDULE

November 2018:
— Begin of project
November 2018 – June 2019:
— Situation Analysis
May – July 2019:
— Development of methods to test
May – October 2019:
— Organization of experiments (faculties, lectures, method refinement and adjustment)
October 2019 – March 2020:
— Scientific experiment
February – April 2020:
— Evaluation of results
June 2020:
— Final Symposium

MAY 2019

MEMBERS Stefan Engels, Stefan Lehner, Judith Paripovic, Pascal Reich, Paul Seiber
TUTORS Konstantin Riedl, Dennis Goldner
MENTOR Prof. Dr. Annette Noschka-Roos



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1. On the one hand we want to increase the quality of communication between students and professors, measured by an outcome evaluation.
2. On the other hand, we want to improve the response rate of evaluations.

RESEARCH QUESTION

Taking into account the boundary conditions of the TUM system, what sort of methodology can be developed to improve the current feedback instruments for teaching at TUM that will

1. tap the full potential of the evaluation process and
2. address the motivation of students, the benefits for lecturers, and the participation rate in lecture evaluation?

WHAT HAPPENED SO FAR?

In the last months, we conducted a comprehensive analysis of the current situation at TUM concerning the course evaluation. At the moment we are in the process of finalizing this research by analyzing and existing questionnaires and the "teacher survey" which recently took place at TUM.

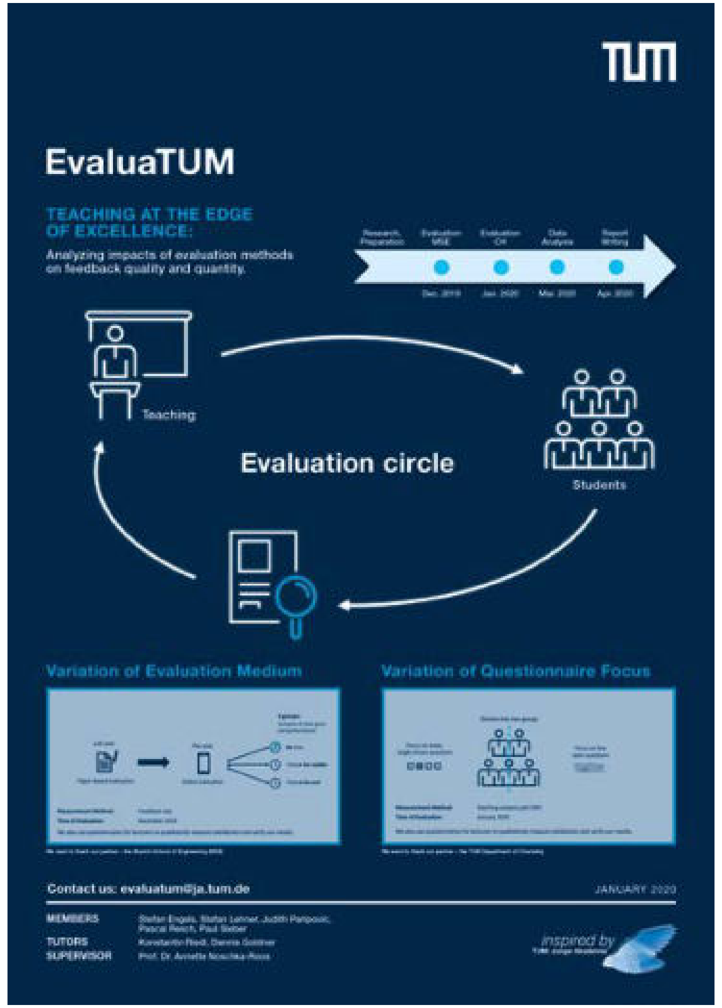
Our goal is to get to know the evaluation process from different perspectives, to establish the right toeholds. Thus, during the winter semester 2019/20, we are going to implement and compare different methods for lecture evaluation with respect to satisfiability, quality of feedback and response rate. We will decide which methods to test in the next weeks after our situational analysis is completed.

WHERE AND HOW SHOULD YOU ADAPT YOUR APPROACH?

Contact us: evaluatum@ja.tum.de

JUNE 2019

MEMBERS Stefan Engels, Stefan Lehner, Judith Paripovic, Pascal Reich, Paul Seiber
TUTORS Konstantin Riedl, Dennis Goldner
MENTOR Prof. Dr. Annette Noschka-Roos



EvaluaTUM

TEACHING AT THE EDGE OF EXCELLENCE:

Analyzing impacts of evaluation methods on feedback quality and quantity.

Research, Preparation
Evaluation MSE
Evaluation CH
Data Analysis
Report Writing
Dec. 2019
Jan. 2020
Mar. 2020
Apr. 2020
Teaching
Evaluation circle
Students

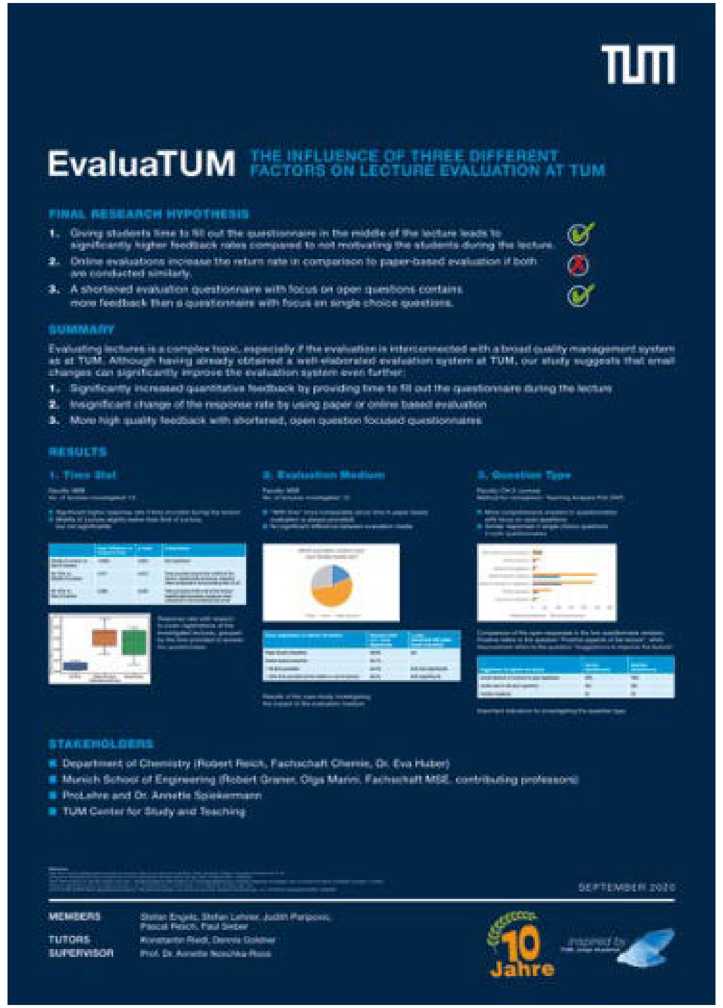
Variation of Evaluation Medium

Variation of Questionnaire Focus

Contact us: evaluatum@ja.tum.de

JANUARY 2020

MEMBERS Stefan Engels, Stefan Lehner, Judith Paripovic, Pascal Reich, Paul Seiber
TUTORS Konstantin Riedl, Dennis Goldner
SUPERVISOR Prof. Dr. Annette Noschka-Roos



EvaluaTUM

THE INFLUENCE OF THREE DIFFERENT FACTORS ON LECTURE EVALUATION AT TUM

FINAL RESEARCH HYPOTHESIS

1. Giving students time to fill out the questionnaire in the middle of the lecture leads to significantly higher feedback rates compared to not motivating the students during the lecture. ✓
2. Online evaluations increase the return rate in comparison to paper-based evaluation if both are conducted similarly. ✗
3. A shortened evaluation questionnaire with focus on open questions contains more feedback than a questionnaire with focus on single choice questions. ✓

SUMMARY

Evaluating lectures is a complex topic, especially if the evaluation is interconnected with a broad quality management system as at TUM. Although having already obtained a well-elaborated evaluation system at TUM, our study suggests that small changes can significantly improve the evaluation system even further:

1. Significantly increased quantitative feedback by providing time to fill out the questionnaire during the lecture
2. Insignificant change of the response rate by using paper or online based evaluation
3. More high quality feedback with shortened, open question focused questionnaires

RESULTS

1. Time Slot

2. Evaluation Medium

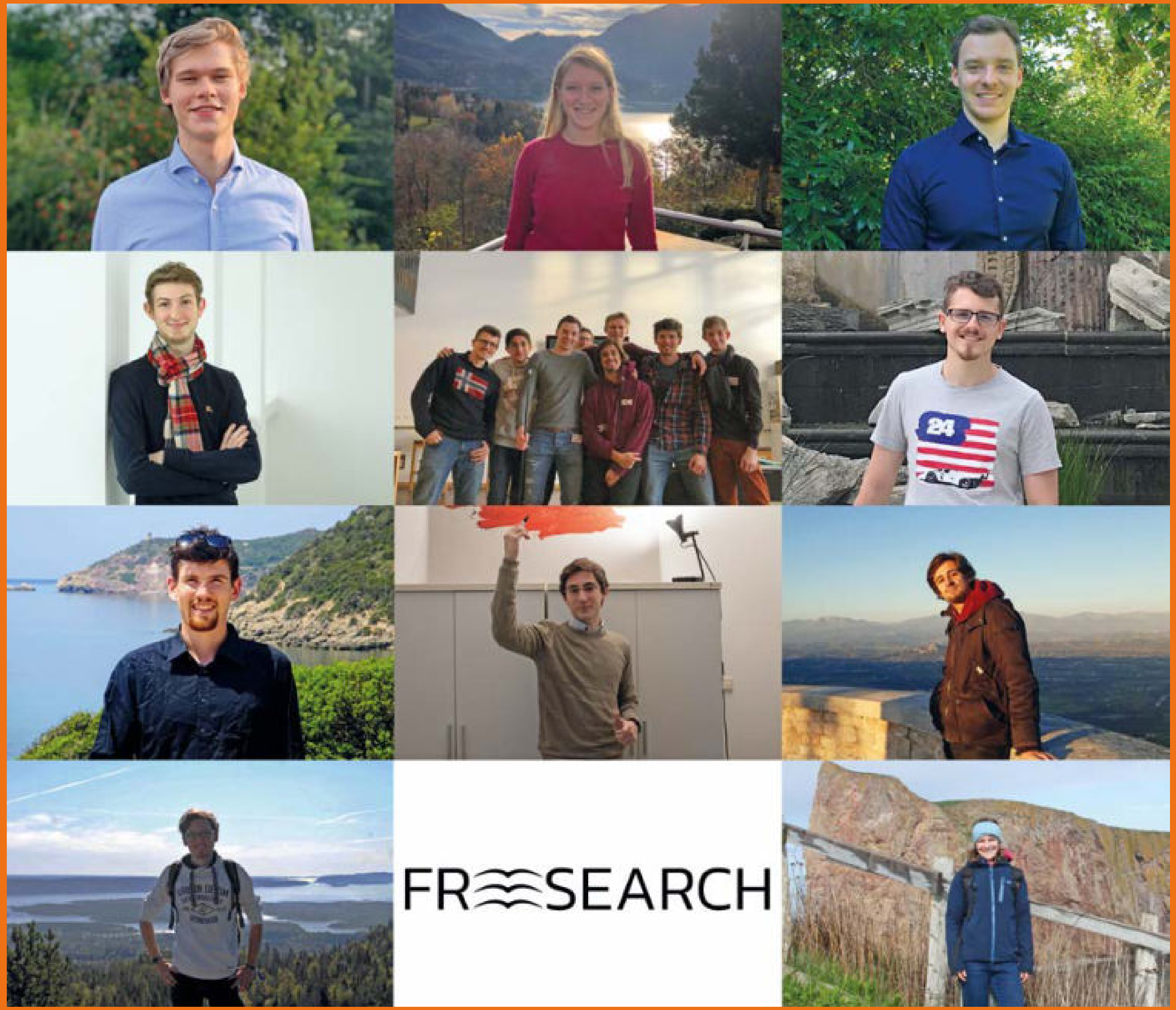
3. Question Type

STAKEHOLDERS

- Department of Chemistry (Robert Reich, Fachschaft Chemie, Dr. Eva Huber)
- Munich School of Engineering (Robert Graner, Olga Marini, Fachschaft MSE, contributing professors)
- ProLehre and Dr. Annette Spiekermann
- TUM Center for Study and Teaching

SEPTEMBER 2020

MEMBERS Stefan Engels, Stefan Lehner, Judith Paripovic, Pascal Reich, Paul Seiber
TUTORS Konstantin Riedl, Dennis Goldner
SUPERVISOR Prof. Dr. Annette Noschka-Roos



Project Report **Freesearch**

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Preface by the Supervisor 118
Journalistic part 120
Scientific part 122
Self reflection 132
Posters 134

Preface by the Supervisor

Prof. Dr. Sonja Berensmeier

Within the call 'Multimodal Science Communication', the Freesearch team started by asking basic questions about the different funding mechanisms and interdependencies of industrial and academic research. A complex story that is difficult to grasp even for professionals and is the subject of continuous controversial discussions. The final idea of the student team to establish a crowdfunding platform for students aiming to solve scientific questions seems to be a very promising and appealing approach.

My own view on the topic is strongly based on the experience of successfully raising public and private funds for scientific research at our university, often together with industry partners or clients. Teaming up with my colleague Tim Lueth, who has additionally founded several companies himself, we tried to challenge the ideas and hypothesis of our student team in order to identify the most relevant "next-problems-to-solve" in order to focus the team on the way forward. We learned that without these intensive coaching activities it is extremely challenging for a newly set up student team to proceed or pivot in a steadily consequential way based on their previous learning instead of jumping arbitrarily on new ideas that they come across.

We were able to observe the different teamworking phases of a very interdisciplinary team – including how they faced the difficulties of aligning their understanding and language to agree on a project problem and their strengths in analyzing the problem and its potential solution from completely different angles. The training sessions of the Junge Akademie and the discussions with their mentors and supervisors were obviously also particularly helpful. The team succeeded in learning to take and defend common decisions after integrating all team members' different opinions and arguments.

Many discussions circled around the definition of science in general. What finally does scientific work mean? How can scientific work be evaluated? Which rules and legal guidelines have to be respected? Which ethical questions could arise? Highly relevant topics, which are not only important for detailing the crowdfunding platform idea, but are critical success criteria for any kind of scientific projects.

However, equally important and powerful, I perceived the regular and open self-reflection of the team and its commitment to optimizing the team results and making any hurdles transparent. The team finally embraced the understanding that a truly scientific way of working means far more than just designing and using statistics: Asking the right questions, capturing and interpreting relevant data and information, testing hypotheses and pivotal ideas until a solution fits the problem – and not forgetting the willingness and ability to accept associated responsibility and compliance with laws and socio-ethical standards.

What did I learn in my supervisor role? Being a member of the Advisory Board of the TUM: Junge Akademie since 2016, it was a valuable experience to be closer to the students and their challenges. I realized again that a scientific way of approaching problems is a long and intense learning journey, until it comes "automatically." And I am again deeply aware of the fact that it is by far easier to avoid falling in love with certain ideas and asking key critical questions if you are able to keep a sufficient distance from a topic. ■

Swarm intelligence as an alternative money source for science?

"Wer zoid, schaffd o.", "The payer determines what happens." Many people agree with this old Bavarian saying. However, problems occur when this rule applies to the foundation of our knowledge: science. This should be independent and free from external influences and manipulation. But is it? Or is that just a pious wish? An example for such manipulation is so-called "Fake Research," which means research funded by companies and distorted so that it suits businesses' interests. Since the 1960s for example, several studies have claimed that smoking is not harmful, on the contrary, it is actually healthy. Those were all funded by the cigarette company Philip Morris. Another case are papers which claim that fossil fuels do not contribute to climate change. Since the 1980s, this theory has been spread by institutes, founded and funded by oil companies like ExxonMobil. The ludicrousness of those examples shows the problem which accompanies this type of science funding: the reality is misrepresented to support a firm's interests. "Wer zoid, schafft o" – also in science.

However, scientific independence comes under pressure from other quarters. Most of the money researchers receive comes from political bodies. In this case, companies and lobby groups exerting influence on the scientific community is not the problem, as who acquires which amount of funding is not directly decided by politicians. Instead, there are institutions which do exactly this – one famous example is the Deutsche Forschungsgemeinschaft (DFG). In order to gain funding, researchers have to meet several criteria. Undergraduates for example suffer vanishingly small chances of obtaining funding, no matter how good their idea is. Additionally, projects which sound good in the context of DFG's application procedure and criteria have a much higher chance of being accepted and receiving funding. Many truly innovative ideas just die because of those criteria.

But are there any alternatives out there? One currently still relatively unknown model has recently gained increasing attention: this is crowdfunding. In this model, researchers upload their idea on a platform and explain their goals and why their topic is so impotant. People can then donate whatever amount of money they want. The big advantage of this concept compared to the two already existing models is the low bar that allows researchers to obtain funding: as long as the idea is good and convincing, they will receive money. Moreover, due to the anonymity of the donors, crowfunding promise to be free from manipulation. However, the question is, how big a potential this model really has.

Recently, a team of researchers at TUM investigated this question. Their findings show two main problems for crowdfunding. Firstly, it takes a lot of time until a crowdfunding platform is famous enough to attract enough donors to really work. Secondly, even if accomplished, it won't be possible to raise such a large amount of money as is usually available through the two other models. This means that crowdfunding can only serve as a supplement to the other two funding models, for example to fund undergraduate projects which are not so expensive.

Despite those two weaknesses: Crowdfunding will have to assert itself at least as part of the new financing mix – if only because the current models are problematic. An enlightened society, which makes its decisions on a scientific basis, therefore needs one main thing: independent scientists who are not subject to manipulation and who can research the best ideas without needing to be the best at filling out forms. Crowdfunding can help here. However, because of the two main weaknesses mentioned, it can only do so in a supporting role within the mix of research funding. ■

Freesearch

Table of contents:

Abstract

Background: A brief introduction to science funding

Goals and Methods

Outcomes and Discussion

Summary and Future Goals

References

Abstract

Advancing science is costly and requires funding. Thus mechanisms to allocate money to scientific projects are needed. Many such mechanisms exist, most notably grant-based public funding and industry sourced funding, but they have been criticized for a variety of shortcomings. Crowdfunding, a novel way of financing projects by pooling funds from a large community, could be used for this purpose. Theoretical considerations show that it may offer distinct advantages particularly in the context of funding small projects, such as student-led or civic science ones. We developed a crowdfunding platform, called crowdTUM, to serve students and alumni of the TUM community, specifically to investigate what are the opportunities and how to overcome the challenges of establishing a crowdfunding platform for scientific projects. We found that the technical and legal implementation of the platform did provide a number of challenges to overcome, most notably organizing the transfer of funds. However, the main challenge was marketing our Crowdfunding initiative. While we managed to host several projects on the platform, we were unable to gather the critical mass of backers necessary to allow projects to get funding. A more concerted social media push, combined with a way of reaching the TUM Alumni community, could potentially have alleviated this problem.

Freesearch: From classical research funding to Crowdfunding

In idealized depictions, science is often regarded as a pursuit "for its own sake." The mathematician G. H. Hardy once argued that "real mathematics must be justified as art if it can be justified at all," and similar attitudes can also be found in other fields.

In practice, however, science, like any other human pursuit, is subject to economic considerations. This has two main reasons: firstly, by adding to the corpus of human knowledge, successful science can translate into new products, higher efficiency, better health or other innovations with considerable economic value; secondly, engaging in science consumes scarce resources. This is obvious for any field where large machines or laboratories are needed. But it is also true of the scholar sitting in a library, as such highly intelligent individuals likely could be usefully employed in many other sectors of the economy.

Accordingly, because science can bring many benefits but also incurs real, substantial costs, society needs mechanisms to decide what resources to allocate to science and how to divide these resources among different fields, projects and scientists.

In this report we will present crowdTUM, a project designed to empirically examine the use of crowdfunding as a funding tool for the scientific projects of TUM students and alumni. The section "Background" will present some criteria to compare mechanisms of science funding, briefly discuss traditional approaches and then discuss crowdfunding in context. Next, the "Goals and Methods" section will present the goals of the crowdTUM case study and the approach used to develop a crowdfunding platform. The "Results" section will critically examine the extent to which these goals have been achieved. Finally the "Conclusion" and "Future Outlook" will offer some general conclusions and opportunities for further research.

Background: A brief introduction to science funding

Theoretical criteria to evaluate science funding mechanisms

To be able to evaluate a science funding mechanism, criteria are needed by which they can be measured and compared. Many such criteria exist in literature and we cannot review all of them here. Instead, we present a few very basic criteria which may serve as a starting point. We propose that a good funding mechanism should:

- **Have low overhead:** the allocation process itself should be fast, not be unduly costly and sufficient money should be available to make participation worthwhile [1].
- **Be Efficient:** Funding should be allocated preferentially to more meritorious projects, as measured by the benefits, costs and probability of success [2].
- **Be Transparent:** criteria used to decide who gets funding should be known and, furthermore, it should be possible to determine how the money has been used and whether the funding has led to conflicts of interest [3].
- **Be Equitable:** everyone with the necessary technical qualifications should be able to participate, regardless of personal characteristics [4].
- **Promote the common good:** the funding mechanism should ensure that the benefits of science are widely shared and help improve society at large.

Of course these criteria are context-dependent, open to interpretation and sometimes mutually contradictory (see for example the conflict between equity and efficiency/ "excellence" [5]). Nevertheless, they provide at least a basis for analysis and comparison between different approaches. It should be noted that major funding agencies, such as the german DFG, often subscribe to these or similar goals. The DFG explicitly lists equality of chances (i.e. equitability) and scientific excellence (efficiency) among its goals, and also sees itself as having a responsibility towards the public [6].

Traditional science funding

Traditionally, a distinction has been made between two main sources of science funding: public and industry. It should be noted that, in practice, each of these come in a variety of forms and additionally many hybrid forms exist. However, the distinction is nevertheless central to many discussions of science funding mechanisms so, accordingly, we will make use of it as well.

Typical examples of public science funding are funding agencies such as the DFG and the horizon program of the EU. The process can be broadly summarized thus: politicians decide on a budget and, in consultation with experts, research priorities. Scientists then write grant applications, i.e. detailed summaries of their proposed projects. A group of peers evaluates these applications and provides recommendations as to which ones should be funded. The main purported advantage of this process is that it allows funding of research which the private sector considers too risky or insufficiently profitable. Accordingly, public funding is often the preferred mechanism to fund basic research, thus promoting the common good by supporting projects that provide revolutionary breakthroughs which ultimately benefit all of society. The world wide web is a commonly cited example [7].

A complaint levied against public funding is that the grant writing process leads to a high overhead. It is alleged that scientists have to spend an excessive amount of their time writing grants [1], reducing the time they have available to do actual science. Another common criticism is that public funding may be inequitable. Research has shown that there is a systematic bias towards established researchers, beyond the degree which could be justified by considerations of efficiency [8].

Industry funding is often considered more flexible. Industry is capable of mobilizing large sums of money and may give researchers more flexibility in using this money. Public funds have been stagnating in many countries, leading to “hypercompetition” between researchers [9]. Industry funding can be used to bypass this problem. Industry-funded research has been found to lead to more patents [10] than publicly funded research. This may indicate on one hand that industry is good at selecting productive projects. However this likely also reflects industry’s desire to generate profits, which limits the extent to which industry-funded science will promote the public good. Additionally, industry funding may be non-transparent and may lead to conflicts of interest [11]. There are also examples of downright unethical practices, such as the manipulation of research on the dangers of smoking [12].

For the specific purpose of funding student-led or citizen science, both mechanisms have large drawbacks. Directly applying for grants will be difficult for outsiders, as will be establishing the necessary contacts with industry. Moreover, such projects are generally non-profit, potentially making them less attractive to industry. Accordingly, students will generally have to work through existing research groups to acquire funds, which may limit their options and creative potential since they do not have full control or responsibility over their project. Examples such as TUM hyperloop, WARR, or TUM: Junge Akademie show that student-led teams are capable of pioneering cutting edge research and engineering.

Crowdfunding

Crowdfunding describes a relatively novel method of funding projects. Instead of relying on traditional financial intermediaries, crowdfunding describes the process of raising funds directly from the community, usually in the form of many small individual contributions, which, given sufficient participation, can add up to a large sum.

Crowdfunding is usually organized through online platforms and generally operates on an all-or-nothing basis. This means that project owners present their projects on the platform, in addition to setting a funding goal. Members of the community (the crowd) then have a specified amount of time to pledge money towards the project. The pledged funds are transferred only if the funding goal is reached in the specified time frame. To entice the crowd to pledge, project owners can specify rewards, often tiered according to the size of the contribution. In contrast to traditional equity investment, these rewards are usually non-financial, though crowdinvesting concepts exist as well [13].

A theoretical evaluation of crowdfunding as funding mechanism

The following analysis considers some theoretical advantages and drawbacks of crowdfunding as a mechanism of science funding.

Criterion	Advantages	Drawbacks
Low overhead	No middleman/expensive layer of bureaucracy between scientists and funders	**Necessity to set up & promote the platform itself to attract projects & funders.** Requires resources (time, marketing) which do not directly contribute to projects/science.
Efficiency	**Projects which are too small to be efficiently funded by traditional mechanisms may become worthwhile in a crowdfunding setting** [14]	Crowd possibly less well equipped to adequately judge the merit of scientific projects compared to domain experts. Could lead to bias towards flashy/entertaining projects, possibly even pseudoscience
Transparency	Crowdfunding encourages scientists to communicate effectively, and, where possible, involve the crowd in their projects [15].	After a project is funded, legal guarantees are limited and project participants may misuse/misappropriate funds
Equitability	**Everyone can participate and barriers to entry are minimal.** Research shows that students are statistically more likely to succeed using crowdfunding than more established researchers [14]	Crowdfunding projects often rely on donations and word to mouth propaganda by friends/relatives, so people with bigger social networks will have an advantage
Promotion of the common good	Donors do not have a profit motive as rewards are non-monetary. This favours non-commercial/idealistic projects. Additionally, by encouraging scientists to communicate with donors, crowdfunding may have educational value.	Not applicable

Table 1: theoretical evaluation of Crowdfunding as Science Funding mechanism

We have emboldened what we consider to be the most essential points. This analysis suggests that crowdfunding may be an effective way for students to acquire funds to undertake their own scientific projects.

Development of our idea

The main goal of our team was to explore ways to improve science and science funding. The name Freesearch, a portmanteau of the words “Free” and “Research,” reflects this.

Initially, we focused on researching existing mechanisms of science funding, with an intent to improve them generally. We quickly realized, however, that this goal was too broad and ill-defined to be achievable.

To limit the scope to something more local, we decided to focus our efforts on student-led research in particular. Since every student at TUM must write a bachelor or master thesis, we decided to embark on a project to help students find thesis topics they are personally passionate about. However, after conducting a survey, we discovered that the demand for such a project was too limited or already partly being served.

We returned to our research on science funding and began to consider whether or not we could improve funding for student-led projects. This led to the current project, to try to explore the possibility of using crowdfunding as a science funding mechanism for student research.

Goals and Methods

As our research points to potential benefits of crowdfunding for student-led research, we decided to try to realize these benefits for TUM students. Doing so, however, requires setting up and evaluating a Crowdfunding platform specific to the TUM community. While it would have also been possible to work through an existing platform, this would have involved some notable disadvantages, as such platforms are (1) not necessarily focused on science or students, (2) not specific to the TUM community and (3) may not be willing to share data openly.

Setting up such a platform entails overcoming a wide variety of challenges, including technical, legal and organizational hurdles. We realized that due to time constraints, it would be very unlikely that we would be able to set up the platform and gather sufficient data on the extent to which it has benefited the community before the end of the TUM: Junge Akademie project period. As a result we decided to focus our research on the process of setting up and populating the platform itself. Specifically, we decided to determine which challenges in particular are faced when establishing a crowdfunding platform for scientific projects and how these can be overcome. As such, our research approach is to construct a testbed and to learn directly from this process.

Technical and Legal Implementation of the Platform

A crowdfunding platform, at the bare minimum, consists of two components: a website, where projects can be advertised to backers, and a method of transferring funds from backers to projects. The website has three fundamental requirements that it must fulfill:

- **Ease of use:** How effective is the website in providing the user with the necessary information? How easy is it for a user to discover and back a campaign?
- **Security:** How secure is the personal data provided to us by the user? How secure is the payments system? Could an adversary steal private information or take down the website?
- **Performance:** Is the website fast enough to handle many users at once? Does the website load the necessary information quick enough so that users do not leave the website and trust the website enough to further conduct transactions?

To guarantee such requirements is a complicated process. Especially in the matters of security and performance, one needs to be quite well informed and proactive to ensure the website runs without issues. Although our team includes informatics students, the limited time frame and budget were prohibitive for us to implement our own systems from scratch. Thus, we have decided to use an existing Platform as a Service solution provided by the LRZ (Leibniz-Rechenzentrum), where we used the existing Wordpress content management system with the Crowdfunding plugin. Our website is set up as a subdomain of the official TUMJA website ja.tum.de. The connection to the website is secured by the modern encryption standard TLS with a certificate provided automatically by the LRZ. While the system we used was not designed to scale to a large number of users, we believed that the potential load provided by our ex-

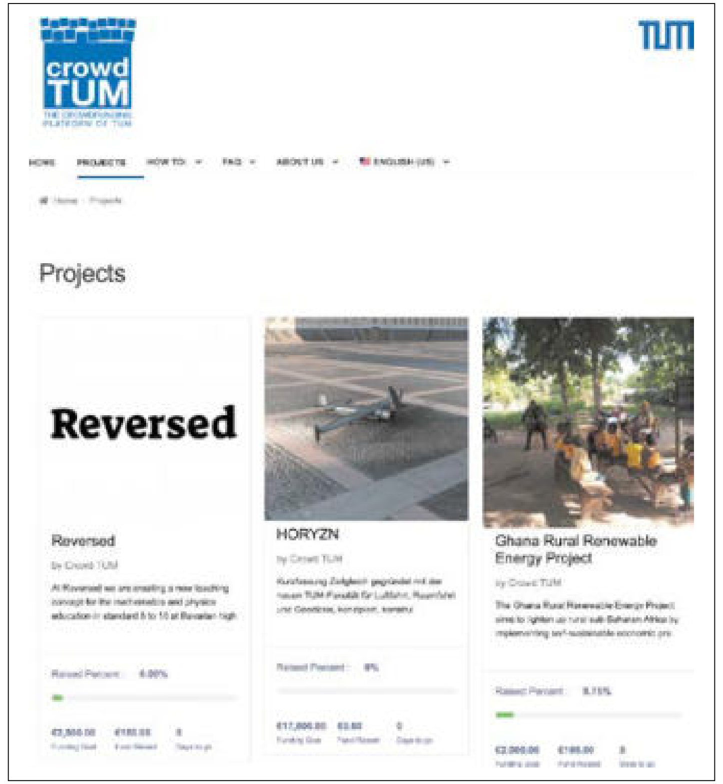

crowd TUM
TUM
HOME
PROJECTS
HOW TO
FAQ
ABOUT US
ENGLISH (US)
Projects
Reversed
Reversed
by Crowd TUM
HORYZN
by Crowd TUM
Ghana Rural Renewable Energy Project
by Crowd TUM

Figure 1: A screenshot of our website

pected number of users could be handled by the single system provided by the LRZ. A more complicated but scalable solution would have only increased both the costs and potential errors in our system.

To implement the transfer of funds, we explored a variety of options, including setting up a company to process the funds directly and paying for a payment processor. We eventually decided to take an indirect approach. When backers pledge funds to a specific project on our platform, it is to be understood as a promise to donate the respective amount if the particular campaign succeeds. Once it does, we sent to backers the account details (of an account managed by the TUM: Junge Akademie) where they should donate to. Then we would send the money to the particular campaign. The advantage of doing it this way is (1) there is no necessity of refunds in case of unsuccessful campaigns, which is a necessary condition to allow funds to be characterized as donations (see below) , and (2) the financial and personal data would all only be handled by TUM. This would also mean that we personally could not be made legally responsible should there have been, for some reason, anything (financially) illegal conducted via crowdTUM. Accordingly, this solution was mainly designed to fulfill legal requirements while minimizing operational risk for us, the users and TUM.

In terms of the legal framework of a crowdfunding platform, two main issues need to be addressed. Firstly, the legal nature of the funding given by backers to projects needs to be determined. We decided to characterize the funds as donations, rather than as payment towards a service, as this does not require setting up a company, drafting contracts or paying taxes. Secondly, compliance with data security provisions needs to be ensured. We did this by using Leibniz Rechenzentrum (LRZ) services to host the platform and by minimizing the amount of personal – particularly financial – data we collect.

For the organizational implementation we developed a set of criteria for scientific projects to satisfy in order to be hosted on the platform. These were inspired by the approach of DFG and required the project to display a scientific approach such as, among others, problem description, solution process, distinguishing features of the solution as well as a clear financial plan.

Marketing the Platform

A crowdfunding platform requires two kinds of users to be successful. Those who desire to set up projects and those who would potentially be willing to fund them.

Our marketing strategy first and foremost was to ensure that there would be some projects on the platform to begin with, so that potential backers wouldn't be met with an empty page. For this purpose, we put up posters advertising the platform and distributed flyers in several university locations. Additionally, we offered a grant, which promised a reward to the first scientific projects to submit to the website, so as to give an incentive for project owners to invest the effort to host their project on our platform.

Project Name	Short description (paraphrased)	Funding goal (Duration)
Ghana Rural Renewable Energy Project	Finding and establishing self-sustainable energy solutions for sub-saharan villages	2000 € (2 months)
Berufsschule Bukit Lawang	Planung und Bau einer handwerklichen Berufsschule in Sumatra mit nachhaltigen Materialien um damit jungen Menschen Ausbildungsplätze und Perspektiven zu schaffen.	5000€ (11 months)
HORYZN	Design and develop a VTOL (Vertical Take.Off and Landing) UAV- (Unmanned Aerial Vehicle) to transport medicine in an easier way to difficult to reach places.	17000€ (3 months)
Reversed	Developing a new engaging teaching concept for the mathematics and physics education at Bavarian high schools based on a modular drone that can be disassembled into individual experiments and thus provides a playful means of exploring physical and mathematical phenomena in an technologically relevant context.	2500€ (2 months)

Table 2: List of projects hosted on the platform

Outcomes and Discussion

The implementation of our crowdfunding platform posed social, technical, and legal/organizational challenges. The social challenge was to promote our platform to both the project creators and funders. The technical challenge was the challenges related to the website and the payment system. The legal/organizational challenges were related to being an intermediary in the transfer of funds between the funders and the project creators.

The Social Challenge

A successful crowdfunding system cannot exist without people willing to create projects and other people willing to fund those projects. To find the people that would be willing to participate in our crowdfunding experiment, we tried different marketing strategies and measured the number of visitors and page views our website received over time.

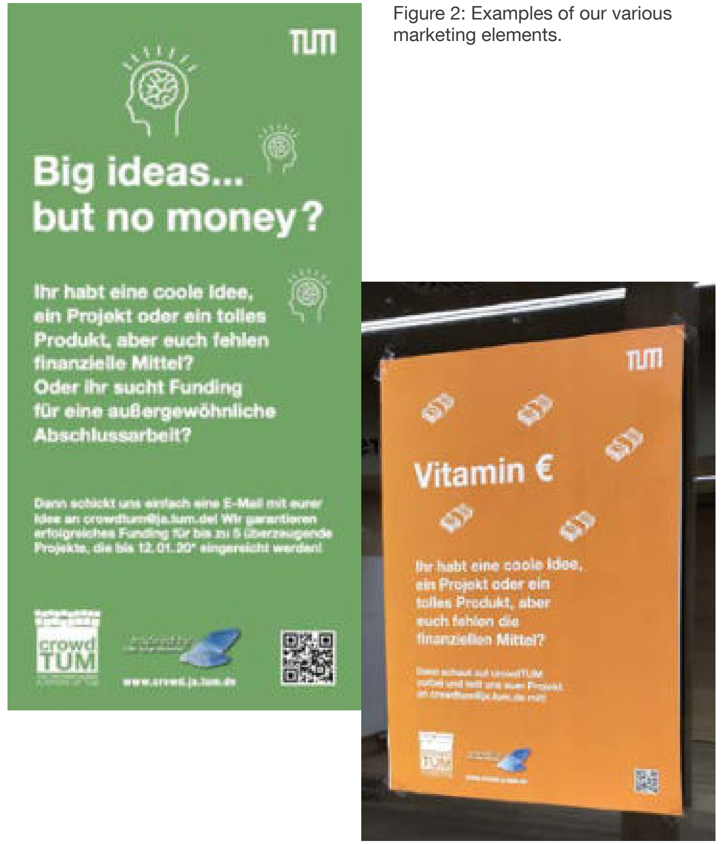

TUM
Big ideas... but no money?
Ihr habt eine coole Idee, ein Projekt oder ein tolles Produkt, aber euch fehlen finanzielle Mittel?
Oder ihr sucht Funding für eine außergewöhnliche Abschlussarbeit?
Dann schickt uns einfach eine E-Mail mit eurer Idee an crowdtum@ja.tum.de! Wir garantieren erfolgreiches Funding für bis zu 5 überzeugende Projekte, die bis 12.01.20* eingereicht werden!
crowd TUM
www.crowd.ja.tum.de
TUM
Vitamin €
Ihr habt eine coole Idee, ein Projekt oder ein tolles Produkt, aber euch fehlen die finanziellen Mittel?

Figure 2: Examples of our various marketing elements.

In Figure 3, the number of visitors to the website is depicted over time in the time range 17.12.2019 - 19.08.2020. The x axis represents the dates and the y axis represents the number of visitors. The black line depicts the number of visitors per date and it's smoothed representation is the horizontal blue line. Three potentially important dates affecting the marketing are displayed as straight vertical lines. The first vertical line in green on the date 16.12.2019 is the day where posters targeting project creators were initially hung over the TUM campus. The second vertical line in blue on the date 10.02.2020 depicts the distribution of flyers around the TUM campus and Mensa-Garching. The third vertical line in red on the date 12.03.2020 depicts the start of a range of travel restrictions concerning Germany due to COVID-19.

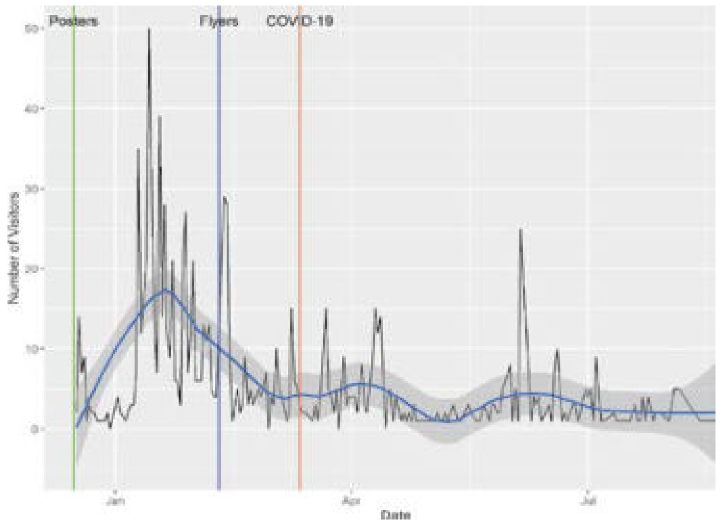


Figure 3: Number of visitors to the CrowdTUM website over time.

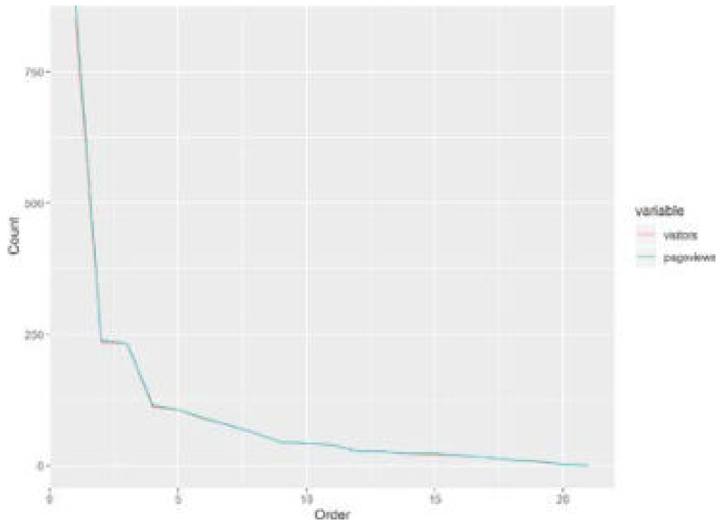


Figure 4: Number of visitors and page views by page, ordered.

The graph shows that while flyers have resulted in a quick and strong peak in views, the peak lasts for a really short time and the website views normalizes to its usual level. Posters, in contrast, result in a much slower change in visitors, but result in a peak that is stronger and lasts longer. It should also be noted that the end of December and the beginning of January correspond to the Christmas/new year holiday which explains the valley of visitor count after the posters were initially hung.

While it has been possible to have some peaks post COVID-19 restrictions via online social media posts and related marketing, we were unable to market the website in a way that could cause the same kind of uptick in views as real physical marketing via posters in the TUM Campus while students still physically attended the university.

There are 5 pages on the website that have been able to garner more than 100 visitors. They are in order:

- The home page with 851 visitors
- The projects page with 236 visitors
- The project “Ghana Rural Renewable Energy” with 233 visitors
- The FAQ with 113 visitors
- The project “HORYZN” with 107 visitors

In Figure 4, the visitors to and page views of pages on the website are displayed. The pages are ordered on the x axis by their views. We can see that there is a small set of pages that are visited a lot of times while the rest of pages are visited significantly less frequently. Additionally, the number of pages seen per visitor is quite close to 1 in our statistics, where we see 1.02 page views per visitor. However, we should note that our website uses as little number of trackers and cookies as possible, so it is technically quite difficult for us to identify separate page views as belonging to the same visitor.

Another interesting statistic is the referrer information we have collected from our website, which denotes where the visitors have come from, in other words, how the visitors discovered our website.

Our most prominent referrers are in order:

- The Junge Akademie website
- Instagram
- Facebook
- Various search engines
- Studinews interview from our team member Jan Kochanowski [16]
- LinkedIn

We can see that promoting the project on the TUM: Junge Akademie website and actively participating on social media platforms led to additional traffic on our website. We also see that official interviews in prominent publications read by the target community lead to increased traffic. A surprising fact is that search engines are not the leading source of referrals. This means that users mostly either wrote down the website URL by themselves by seeing it on our marketing or discovered the URL through the other sources. Our referrals data also shows us that the most prominently viewed project “Ghana Rural Renewable Energy” has conducted additional marketing on LinkedIn. This leads us to believe that projects conducting independent marketing can result in an important increase in their engagement.

The Technical Challenge

The technical challenge proved to be less difficult than expected, as we had the right skills and tools to confront this challenge. One team member is a very experienced programmer and thus had the right skillset to master this task. Additionally, thanks to the availability of services like wordpress and the LRZ web hosting, the technical overhead necessary to create and maintain the website has become very manageable. Furthermore support from the TUM “Referat für Datenschutz” proved highly valuable in demystifying and following privacy law requirements. Overall the support of TUM: Junge Akademie was very helpful.

The Legal/Organizational Challenge

The third and final challenge was the issue of the transfer of funds, which proved more difficult. We had neither a legal nor an entrepreneurial expert in our team, which meant that our ability to fully explore the space of possibilities was limited in this case. We settled for the option relying on voluntary commitments, as explained previously in the “Methods” section. This approach means that the platform never comes into contact with any funds or financial data. It, however, has the distinct disadvantage that backers may renege on their promise when the time comes to donate, or simply forget, which has the very unfortunate side effect that successful campaigns may not actually receive the funds they were hoping for. Thus, while this probably was the best we could achieve given our lack of experience in this area, this is not a fully satisfactory solution.

Related to this was the issue of how to classify funds. As previously mentioned, we opted for classifying them as donations, which coincides well with the non-profit nature of our mission and also means that backers would be able to benefit from tax-deductions. However, this comes with two disadvantages. Firstly, backers have little legal recourse if project owners fail to make good on their promises. Secondly, donations generally are non-refundable, which was also part of the reason why we organized the transfer of funds using the model of voluntary commitments.

Discussion

Marketing the platform proved more difficult than the technical and legal implementation. Initially we believed that the main challenge would be finding interesting projects, and indeed it required some time after launch until we managed to get a project on the platform. In this regard our efforts, particularly the grant, were successful, and we finally managed to have four projects hosted on the platform. Additionally, our marketing efforts also were able to draw some traffic to the site, at least during our marketing pushes. Unfortunately, only a very small number of the people visiting the site decided to visit the projects individual sites, or contribute funds, meaning that, ultimately, no project was successfully funded.

There are several possible explanations for this. Firstly, it is likely that the overall traffic generated was too low to really drive enough potential backers to the platform. While we did attempt some social media based marketing, we were not able to make the platform “go viral”.

Secondly, our marketing efforts mostly focused on TUM students. Alumni, however, likely would have access to more funds, but our marketing methods were not capable of reaching them effectively. In this regard, developing a marketing strategy designed to reach Alumni would have possibly helped, although this probably would have required a cooperative effort with the TUM Alumni organizations which were somewhat reluctant to become involved.

Alternatively acquiring reputable projects that were better known could have driven more backers to the platform.

In order to reach more and more popular projects we at some point weakened the rather strict requirement of needing to be scientific and allowed all sorts of projects. We tried to achieve this by talking with the student group “Enactus” about helping them fund some of their social-entrepreneurial projects, which are very well known.

Challenge	Level of difficulty	Explanation
Technical: Programming the Website	🙂	Many templates exist, one team member is an experienced engineer
Technical: Implementing a Method to transfer funds	😐	Solution that does not rely on voluntary commitments would require setting up a company
Legal: creating a data protection plan	🙂	Leibniz Rechenzentrum services and the TUM „Referat für Datenschutz“ make this relatively easy
Legal: deciding the legal character of the funds	😐	Donations come with no legal complications and offer tax advantages, but are nonrefundable
Social: getting projects on the platform	😐	The poster campaign and grant allowed us to get 4 projects to the website
Social: getting potential backers to the platform	☹	Our offline and social media efforts were insufficient reach enough possible backers

Table 3: The main challenges in developing a working Crowdfunding platform.

Summary and Future Goals

Developing a crowdfunding platform for the TUM community involved a variety of different challenges. Initially, we focused on the technical and legal aspects. While we could not find a satisfactory solution to every legal issue, we nevertheless managed to develop a fully functional crowdfunding platform. Furthermore, in the future, it could be possible to address some of the lingering issues. For example, one could “name and shame” donors who renege on their promise to donate, so as to reduce the likelihood of donors reneging on their promise. Alternatively, one could move beyond the voluntary model entirely by setting up a company or a non-profit organization and possibly moving beyond a donation model. The first would imply large initial costs, and also means that taxes would need to be paid, but it would offer more flexibility in the long run.

The biggest challenge proved to be attracting a large enough number of potential backers. We did not focus on this issue early enough and thus did not place enough importance on this point in our marketing strategy, since we emphasized attracting projects more. In retrospect, it has become clear that we underestimated this hurdle. A more effective social media advertising push combined with some method of directly reaching Alumni and some amount of funding prior to launching the platform may have alleviated this problem somewhat. Overall a greater integration with the different organizations of TUM, like UnternehmerTUM, could be greatly beneficial.

During the Corona Pandemic, we developed the idea that the platform could be used as a way to help students who are facing financial difficulties. Specifically, we envisioned that funds could be raised through Crowdfunding and then distributed as “care packages” to TUM students in need. This work is still ongoing. ■

References

1. Fang FC, Casadevall A. NIH peer review reform-change we need, or lipstick on a pig? Infect Immun. 2009; 77: 929–932.
2. Li D, Agha L. Research funding. Big names or big ideas: do peer-review panels select the best science proposals? Science. 2015;348: 434–438.
3. Peerenboom E. Transparent science. Nature adopts new guidelines asking authors to disclose potential conflicts of interest. EMBO Rep. 2002; 3: 9–11.
4. Winder L, Hodge S. A manifesto for fair and equitable research funding in ecology. ReEco. 2017; 2: 47–56.
5. Hicks D, Katz JS. Equity and Excellence in Research Funding. Minerva. 2011; 49: 137–151.
6. DFG - Deutsche Forschungsgemeinschaft – Was ist die DFG? [cited 5 Aug 2020]. Available: https://www.dfg.de/dfg_profil/aufgaben/was_ist_die_dfg/index.html
7. The birth of the Web | CERN. [cited 29 Mar 2020]. Available: https://home.cern/science/computing/birth-web
8. Wahls WP. High cost of bias: Diminishing marginal returns on NIH grant funding to institutions. Scientific Communication and Education. bioRxiv; 2018. p. e989.
9. Janger J, WIFO, Schmidt N, Strauss A. International differences in basic research grant funding – a sytematic comparison. 2019. doi: 10.22163/fteval.2019.345
10. Hottenrott H, Thorwarth S. Industry Funding of University Research and Scientific Productivity. Kyklos. 2011; 64: 534–555.
11. Sismondo S. How pharmaceutical industry funding affects trial outcomes: causal structures and responses. Soc Sci Med. 2008; 66: 1909–1914.
12. Bero LA. Tobacco industry manipulation of research. Public Health Rep. 2005; 120: 200–208.
13. Orthwein I. Crowdfunding: Grundlagen und Strategien für Kapitalsuchende und Geldgeber. Igel Verlag RWS; 2014.
14. Sauermann H, Franzoni C, Shafi K. Crowdfunding scientific research: Descriptive insights and correlates of funding success. PLoS One. 2019; 14: e0208384.
15. Researcher Guide - Extra. In: Experiment – Moving Science Forward [Internet]. [cited 29 Mar 2020]. Available: https://experiment.com/guide/extra

Self Reflection

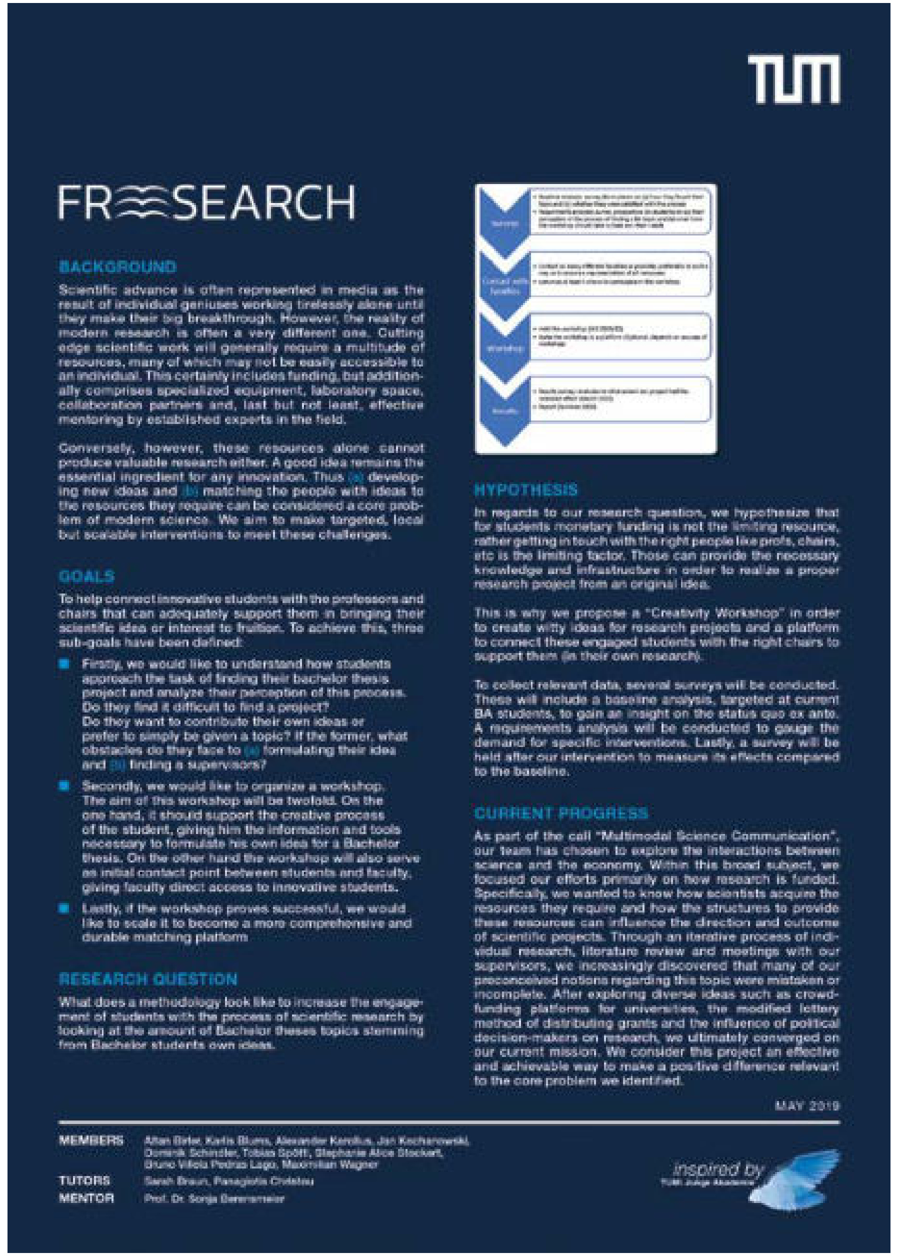
The initial problem we set out to tackle was the science funding system. We spent a lot of time brainstorming and developing ideas on how best we might contribute to improving this system. We started working on many different approaches to our original question. But either we could not find consensus among all – or even most – of the team members, or we thought we had found a better, more original, or more effective approach. Due to the size of the team of nine members, it was difficult to arrive at a solution with which every team member agreed. That was particularly evident in the early stages of the project while we were sharing our creative ideas, opinions, and enthusiasms. As a result, the meetings were long and full of often unnecessary discussions. Our inexperience and the fact that the tutors could not always be present meant that we were not able to cut down on our inefficient use of time. However, we were always willing to compromise and to agree to a particular direction for the project if the majority of the team were behind it. This indecisiveness and lack of a unified project goal that every member was passionate about cost us, our tutors, and supervisors a lot of energy and time. It also meant that we were only able to decide on building a crowdfunding platform for TUM very late in the project phase. However, we finally had to make a permanent decision. Once some of us had agreed on the crowdfunding approach, we then had one common achievable goal that everyone seemed happy to contribute to, which was very helpful.

The second major problem we faced as a team internally was how to balance and resolve the rather different expectations of all interested parties. It was difficult for us to find a way that would implement our own visions for the project, while at the same time allowing for our shortcomings and satisfying external requirements from (in summary form): a) the project management side of TUMJA (Dr. Alexander Lang, Dr. Matthias Lehner) who were most interested in the concrete implementation of our project; b) the office of TUMJA (Peter Finger and Maria Hannecker), who always had new and interesting suggestions that we might follow; c) our supervisors (Prof. Sonja Berensmeier, Prof. Tim Lüth), who were very keen on and interested in a proper scientific approach; and d) the Fundraising Department of TUM, who were most interested in the results of our research. We are very grateful to all parties for their help and commitment, and we know that we have not always made it easy for them – and especially for the very busy Prof. Tim Lüth, who was not even an official supervisor of TUMJA, but who was nevertheless very motivated to help and support us. In the end, we think we have achieved something with which every party involved can be satisfied and, for ourselves, we feel we have learned a lot from having to deal with such seemingly orthogonal external demands on our team's work.

When the corona pandemic hit Europe, we already considered our main project work to be over. Therefore, we collectively decided to use the platform we had created for doing some further good by helping students who were in financial difficulties at the time due to the contact restrictions. Since our entire team was behind this great idea, we managed to do the necessary work very quickly and effectively, to contact the people involved and to have all things running internally within two months. This was proof of the skills that all of us had gained during our project phase. However, due to external factors, mainly the financial department of TUM, which was not able to support our charitable work, we were never able to launch our "COVID-19 support packages." But we have learned from those setbacks.

Acknowledgments

We are thankful to the people who have supported our ideas, giving feedback and insight. In particular, we would like to acknowledge and thank our supervisors Prof. Sonja Berensmeier and Prof. Tim Lüth, who both gave us some of their valuable time to teach and guide us. Our tutor Sarah Braun brought us back to more fruitful discussions whenever we lost our way. The designer Ulrich Leyermann worked with us to create a visual identity for our platform. Also, we are grateful to the President of TUM, Thomas F. Hofmann, and the TUM Fundraising Department for their explicit interest in our work and to SVP Gerhard Müller for his encouragement. We thank the Referat für Datenschutz and the Financial Department of TUM for their help, and, of course, Peter Finger and Maria Hannecker from the TUMJA office for always helping and encouraging us and for all of their organizational work. Finally, thanks to the students who had faith in our work and offered their projects to be backed on CrowdTUM!



TUM

FREESEARCH

BACKGROUND

Scientific advance is often represented in media as the result of individual geniuses working tirelessly alone until they make their big breakthrough. However, the reality of modern research is often a very different one. Cutting edge scientific work will generally require a multitude of resources, many of which may not be easily accessible to an individual. This certainly includes funding, but additionally comprises specialized equipment, laboratory space, collaboration partners and, last but not least, effective mentoring by established experts in the field.

Conversely, however, these resources alone cannot produce valuable research either. A good idea remains the essential ingredient for any innovation. Thus (a) developing new ideas and (b) matching the people with ideas to the resources they require can be considered a core problem of modern science. We aim to make targeted, local but scalable interventions to meet these challenges.

GOALS

To help connect innovative students with the professors and chairs that can adequately support them in bringing their scientific idea or interest to fruition. To achieve this, three sub-goals have been defined:

- Firstly, we would like to understand how students approach the task of finding their bachelor thesis project and analyze their perception of this process. Do they find it difficult to find a project? Do they want to contribute their own ideas or prefer to simply be given a topic? If the former, what obstacles do they face to (a) formulating their idea and (b) finding a supervisors?
- Secondly, we would like to organize a workshop. The aim of this workshop will be twofold. On the one hand, it should support the creative process of the student, giving him the information and tools necessary to formulate his own idea for a Bachelor thesis. On the other hand the workshop will also serve as initial contact point between students and faculty, giving faculty direct access to innovative students.
- Lastly, if the workshop proves successful, we would like to scale it to become a more comprehensive and durable matching platform

RESEARCH QUESTION

What does a methodology look like to increase the engagement of students with the process of scientific research by looking at the amount of Bachelor theses topics stemming from Bachelor students own ideas.

HYPOTHESIS

In regards to our research question, we hypothesize that for students monetary funding is not the limiting resource, rather getting in touch with the right people like profs, chairs, etc is the limiting factor. Those can provide the necessary knowledge and infrastructure in order to realize a proper research project from an original idea.

This is why we propose a "Creativity Workshop" in order to create witty ideas for research projects and a platform to connect these engaged students with the right chairs to support them (in their own research).

To collect relevant data, several surveys will be conducted. These will include a baseline analysis, targeted at current BA students, to gain an insight on the status quo ex ante. A requirements analysis will be conducted to gauge the demand for specific interventions. Lastly, a survey will be held after our intervention to measure its effects compared to the baseline.

CURRENT PROGRESS

As part of the call "Multimodal Science Communication", our team has chosen to explore the interactions between science and the economy. Within this broad subject, we focused our efforts primarily on how research is funded. Specifically, we wanted to know how scientists acquire the resources they require and how the structures to provide these resources can influence the direction and outcome of scientific projects. Through an iterative process of individual research, literature review and meetings with our supervisors, we increasingly discovered that many of our preconceived notions regarding this topic were mistaken or incomplete. After exploring diverse ideas such as crowdfunding platforms for universities, the modified lottery method of distributing grants and the influence of political decision-makers on research, we ultimately converged on our current mission. We consider this project an effective and achievable way to make a positive difference relevant to the core problem we identified.

MAY 2019

MEMBERS Altan Birlar, Karlis Blums, Alexander Kandlus, Jan Kocharowski, Dominik Schindler, Tobias Spöttl, Stephanie Alice Stockert, Bruno Villela Pedras Lago, Maximilian Wagner

TUTORS Sarah Braun, Panagiotis Chatzinas

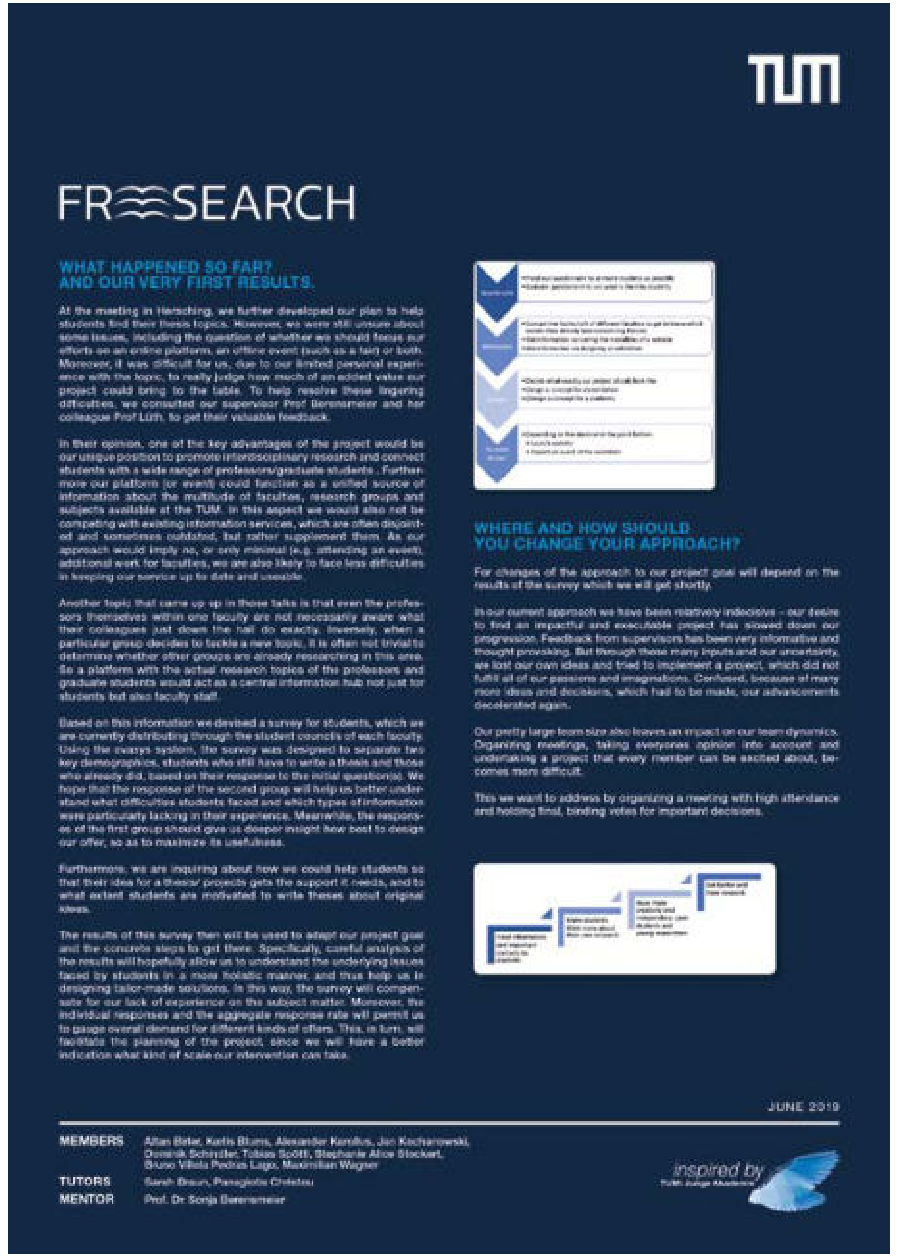
MENTOR Prof. Dr. Sonja Berensmeier

inspired by TUM: Junge Akademie

POSTER 1: Team Freesearch started into its project planning right at the Kick-Off Weekend. Our basic question at that time was: What influences the results of science? In a relatively short time, we realized that we could base our project on two broad approaches: either investigating factors not (directly) related to money or exploring the ways in which the current system of science funding is flawed.

Both approaches suggested two projects. On the one hand, a project considering how science outcomes can be influenced by the trends in the scientific community and by cliques among researchers. On the other hand, a project looking at how researchers, and especially students, find it difficult to develop a scientific idea, even if it is very innovative. For example, students rarely know which chair to contact when they have an idea. At the same time, the chairs obviously cannot be aware in advance of which students may have good ideas.

The hypothesis that science funding is flawed led us towards the idea of two alternative ways which could help to distribute money more fairly to scientific projects. First, there is the so-called "modified lottery," a system in which money is provided randomly to projects which fulfill certain criteria. Secondly, we learned about a mechanism called "Crowdfunding," where anybody can place a project on a website and anybody interested in this project can help to finance it through a donation. ■



TUM

FREESEARCH

WHAT HAPPENED SO FAR? AND OUR VERY FIRST RESULTS.

At the meeting in Herrsching, we further developed our plan to help students find their thesis topics. However, we were still unsure about some issues, including the question of whether we should focus our efforts on an online platform, an offline event (such as a fair) or both. Moreover, it was difficult for us, due to our limited personal experience with the topic, to really judge how much of an added value our project could bring to the table. To help resolve these lingering difficulties, we consulted our supervisor Prof Berensmeier and her colleague Prof Lüth, to get their valuable feedback.

In their opinion, one of the key advantages of the project would be our unique position to promote interdisciplinary research and connect students with a wide range of professors/graduate students . Furthermore our platform (or event) could function as a unified source of information about the multitude of faculties, research groups and subjects available at the TUM. In this aspect we would also not be competing with existing information services, which are often disjointed and sometimes outdated, but rather supplement them. As our approach would imply no, or only minimal (e.g. attending an event), additional work for faculties, we are also likely to face less difficulties in keeping our service up to date and useable.

Another topic that came up up in these talks is that even the professors themselves within one faculty are not necessarily aware what their colleagues just down the hall do exactly. Inversely, when a particular group decides to tackle a new topic, it is often not trivial to determine whether other groups are already researching in this area. So a platform with the actual research topics of the professors and graduate students would act as a central information hub not just for students but also faculty staff.

Based on this information we devised a survey for students, which we are currently distributing through the student councils of each faculty. Using the [illegible] system, the survey was designed to separate two key demographics, students who still have to write a thesis and those who already did, based on their response to the initial question(s). We hope that the responses of the second group will help us better understand what difficulties students faced and which types of information were particularly lacking in their experience. Meanwhile, the responses of the first group should give us deeper insight how best to design our offer, so as to maximize its usefulness.

Furthermore, we are inquiring about how we could help students so that their idea for a thesis/ projects gets the support it needs, and to what extent students are motivated to write theses about original ideas.

The results of this survey then will be used to adapt our project goal and the concrete steps to get there. Specifically, careful analysis of the results will hopefully allow us to understand the underlying issues faced by students in a more holistic manner and thus help us in designing tailor-made solutions. In this way, the survey will compensate for our lack of experience on the subject matter. Moreover, the individual responses and the aggregate response rate will permit us to gauge overall demand for different kinds of offers. This, in turn, will facilitate the planning of the project, since we will have a better indication what kind of scale our intervention can take.

WHERE AND HOW SHOULD YOU CHANGE YOUR APPROACH?

For changes of the approach to our project goal will depend on the results of the survey which we will get shortly.

In our current approach we have been relatively indecisive – our desire to find an impactful and executable project has slowed down our progression. Feedback from supervisors has been very informative and thought provoking. But through these many inputs and our uncertainty, we lost our own ideas and tried to implement a project, which did not fulfill all of our passions and imaginations. Confused, because of many more ideas and decisions, which had to be made, our advancements decelerated again.

Our pretty large team size also leaves an impact on our team dynamics. Organizing meetings, taking everyones opinion into account and undertaking a project that every member can be excited about, becomes more difficult.

This we want to address by organizing a meeting with high attendance and holding final, binding votes for important decisions.

JUNE 2019

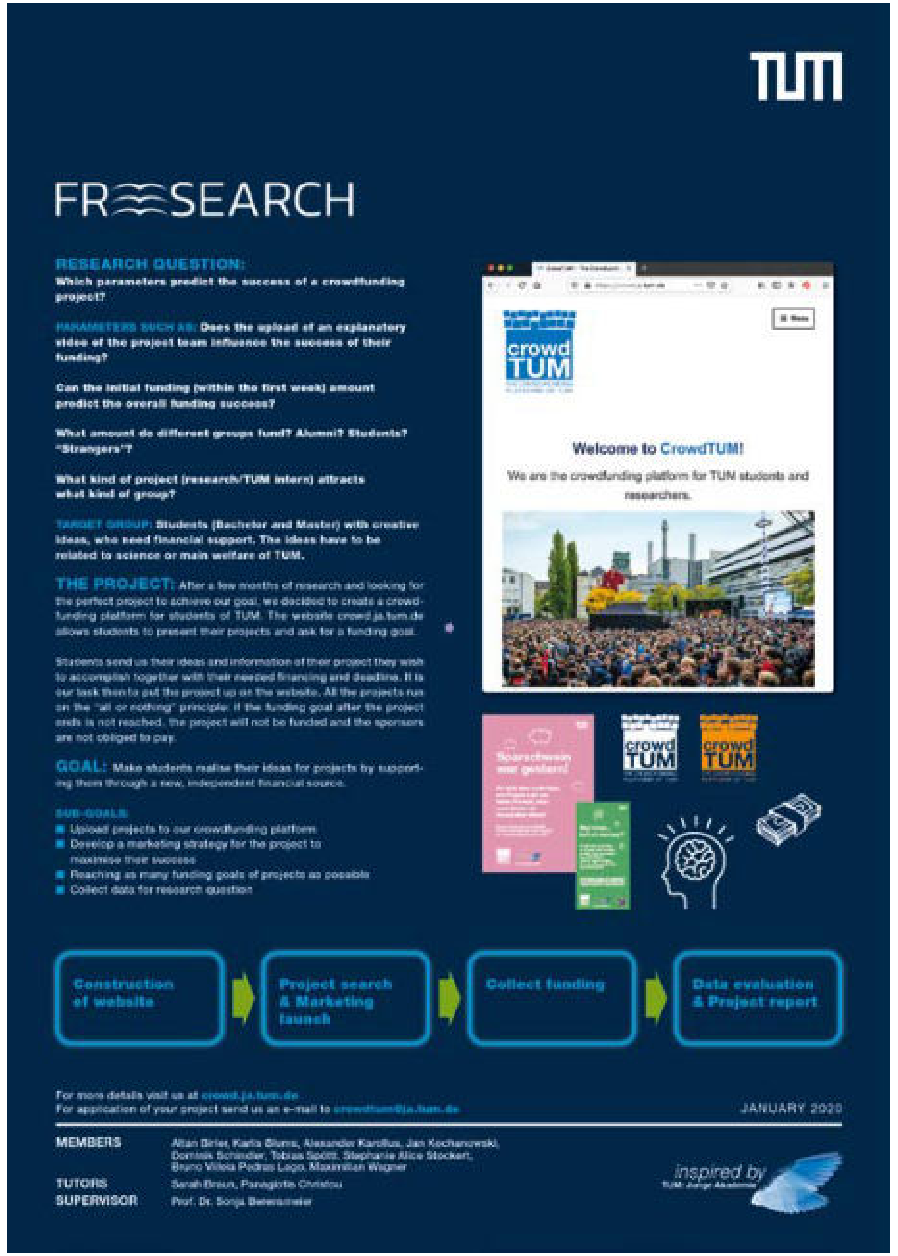
MEMBERS Altan Birlar, Karlis Blums, Alexander Kandlus, Jan Kocharowski, Dominik Schindler, Tobias Spöttl, Stephanie Alice Stockert, Bruno Villela Pedras Lago, Maximilian Wagner

TUTORS Sarah Braun, Panagiotis Chatzinas

MENTOR Prof. Dr. Sonja Berensmeier

inspired by TUM: Junge Akademie

POSTER 2: So, which of these four ideas would we choose to base our project on? At the beginning, we did some research on all the approaches. Step by step, we found more and more problems with three of the ideas. The trend analysis would have been too abstract, and moreover, we could not imagine a good scientific project arising from this idea. For the problem of students not knowing where to go with a project idea, we came up with a provisional project called "TinderTUM" in which we would create a platform (either web-based or a based on a convention), which would match students and their ideas with the chairs. However, the problem with this idea was that the faculty of Maschinenbau already had something similar (the LOIFT), and we wanted to come up with something new. For the concept of a modified lottery, we also had problems with thinking of an implementation which would not be too far away from the "real" concept. ■



FR≋SEARCH

RESEARCH QUESTION:
Which parameters predict the success of a crowdfunding project?

PARAMETERS SUCH AS: Does the upload of an explanatory video of the project team influence the success of their funding?

Can the initial funding (within the first week) amount predict the overall funding success?

What amount do different groups fund? Alumni? Students? "Strangers"?

What kind of project (research/TUM intern) attracts what kind of group?

TARGET GROUP: Students (Bachelor and Master) with creative ideas, who need financial support. The ideas have to be related to science or main welfare of TUM.

THE PROJECT: After a few months of research and looking for the perfect project to achieve our goal, we decided to create a crowdfunding platform for students of TUM. The website crowd.ja.tum.de allows students to present their projects and ask for a funding goal.

Students send us their ideas and information of their project they wish to accomplish together with their needed financing and deadline. It is our task then to put the project up on the website. All the projects run on the "all or nothing" principle: If the funding goal after the project ends is not reached, the project will not be funded and the sponsors are not obliged to pay.

GOAL: Make students realise their ideas for projects by supporting them through a new, independent financial source.

SUB-GOALS:
- Upload projects to our crowdfunding platform
- Develop a marketing strategy for the project to maximise their success
- Reaching as many funding goals of projects as possible
- Collect data for research question

Welcome to CrowdTUM!

We are the crowdfunding platform for TUM students and researchers.

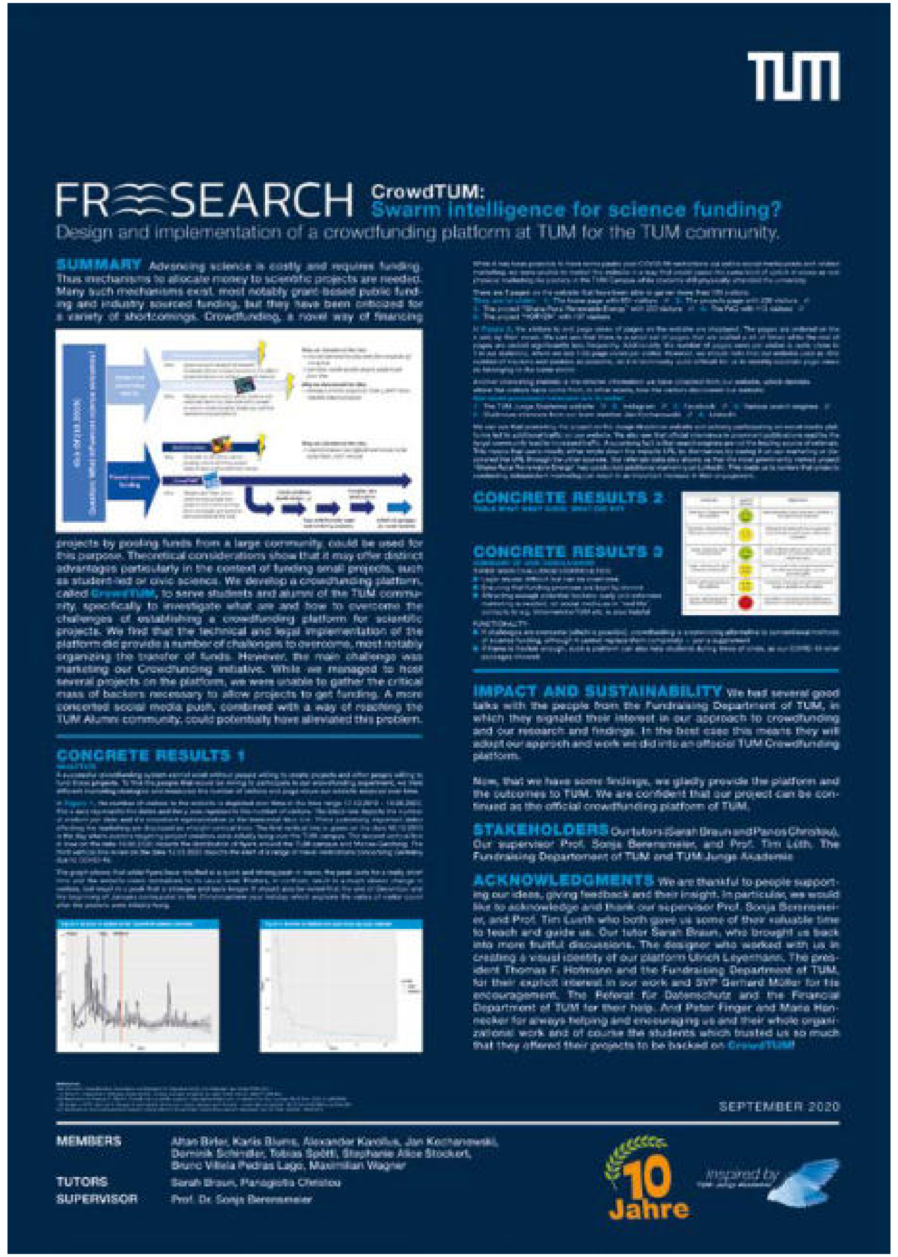
Construction of website → **Project search & Marketing launch** → **Collect funding** → **Data evaluation & Project report**

For more details visit us at crowd.ja.tum.de
For application of your project send us an e-mail to crowdtum@ja.tum.de

JANUARY 2020

MEMBERS Altan Birler, Karla Blums, Alexander Karollus, Jan Kochanowski, Dominik Schindler, Tobias Spöttl, Stephanie Alice Stockert, Bruno Villela Pedras Lago, Maximilian Wagner
TUTORS Sarah Braun, Panagiotis Christou
SUPERVISOR Prof. Dr. Sonja Berensmeier

POSTER 3: In the end, we decided to focus on one idea: the crowdfunding concept. The project arising from this idea was easy to envisage. We would create a crowdfunding platform for the TUM community to help students realize their ideas through the support of the TUM community. The research phase was about finding out which parts of this concept might work well and which might not. We started designing and building the platform. In the process, we also had to cope with financial, legal, and marketing problems, which we were able partly to overcome with the help of corresponding offices and departments of TUM. Afterwards, we had two phases in which we first searched for and found relevant projects and then tried to raise funding for them. These projects were unsuccessful because the platform was not yet well known and therefore not enough donations were received. ■



FR≋SEARCH **CrowdTUM: Swarm intelligence for science funding?**
Design and implementation of a crowdfunding platform at TUM for the TUM community.

SUMMARY Advancing science is costly and requires funding. Thus mechanisms to allocate money to scientific projects are needed. Many such mechanisms exist, most notably grant-based public funding and industry sourced funding, but they have been criticized for a variety of shortcomings. Crowdfunding, a novel way of financing projects by pooling funds from a large community, could be used for this purpose. Theoretical considerations show that it may offer distinct advantages particularly in the context of funding small projects, such as student-led or civic science. We develop a crowdfunding platform, called CrowdTUM, to serve students and alumni of the TUM community, specifically to investigate what are and how to overcome the challenges of establishing a crowdfunding platform for scientific projects. We find that the technical and legal implementation of the platform did provide a number of challenges to overcome, most notably organizing the transfer of funds. However, the main challenge was marketing our Crowdfunding initiative. While we managed to host several projects on the platform, we were unable to gather the critical mass of backers necessary to allow projects to get funding. A more concerted social media push, combined with a way of reaching the TUM Alumni community, could potentially have alleviated this problem.

CONCRETE RESULTS 1

CONCRETE RESULTS 2

CONCRETE RESULTS 3

IMPACT AND SUSTAINABILITY We had several good talks with the people from the Fundraising Department of TUM, in which they signaled their interest in our approach to crowdfunding and our research and findings. In the best case this means they will adopt our approach and work we did into an official TUM Crowdfunding platform.

Now, that we have some findings, we gladly provide the platform and the outcomes to TUM. We are confident that our project can be continued as the official crowdfunding platform of TUM.

STAKEHOLDERS Our tutors (Sarah Braun and Panos Christou), Our supervisor Prof. Sonja Berensmeier, and Prof. Tim Lüth. The Fundraising Department of TUM and TUM Junge Akademie

ACKNOWLEDGMENTS We are thankful to people supporting our ideas, giving feedback and their insight. In particular, we would like to acknowledge and thank our supervisor Prof. Sonja Berensmeier, and Prof. Tim Lueth who both gave us some of their valuable time to teach and guide us. Our tutor Sarah Braun, who brought us back into more fruitful discussions. The designer who worked with us in creating a visual identity of our platform Ulrich Leyermann. The president Thomas F. Hofmann and the Fundraising Department of TUM for their explicit interest in our work and SVP Gerhard Müller for his encouragement. The Referat für Datenschutz and the Financial Department of TUM for their help. And Peter Finger and Maria Hannecker for always helping and encouraging us and their whole organizational work and of course the students which trusted us so much that they offered their projects to be backed on CrowdTUM!

SEPTEMBER 2020

MEMBERS Altan Birler, Karla Blums, Alexander Karollus, Jan Kochanowski, Dominik Schindler, Tobias Spöttl, Stephanie Alice Stockert, Bruno Villela Pedras Lago, Maximilian Wagner
TUTORS Sarah Braun, Panagiotis Christou
SUPERVISOR Prof. Dr. Sonja Berensmeier

POSTER 4: After the project phase was extended due to the corona pandemic, we decided to use the platform ourselves for a good cause: COVID-19 support packages for students who have fallen into financial difficulties due to the pandemic. Currently, there are still a few challenges that we need to overcome to make the platform work successfully. ■

Project Report **MUCtrail**

Team	Beate Neu Jessica Neußer Johaina Kullab Niklas Dreymann Nitish Nagesh
Tutors	Andreas Wenniger Maximilian Bauer

Preface by the Tutor 140
Journalistic part 142
Scientific part 144
Self reflection 152
Posters 154

Preface by the Tutor

Maximilian Bauer

In the first months of 2020, the call for scientific expertise became loud among policymakers and society at large in response to the COVID-19 pandemic. Nevertheless, experience in many areas shows that the actions of individuals and society are not always guided by scientific evidence. Such science denial, for instance, can result in fewer children being vaccinated.

When the team formed in late 2018, the five students set themselves the goal of reducing that gap between science and society as team sciencíety. This venture resulted in MUCtrail, an interactive adventure trail that introduces the scientific method to children (and the generations of their parents and grandparents) in a playful way. By exploring various stations, centered around the topic of urban climate and built upon a mobile web application, visitors to the Olympic Park can learn the basics of scientific work: observing, generating hypotheses, testing in experiments, and drawing conclusions from data.

The underlying idea behind this approach is the observation that knowledge of the scientific method is limited in large parts of the population. Around this main observation, the realization of the project was remarkable in several aspects:

When I joined to support the team, I had some concerns regarding the vague objectives behind the original sciencíety concept. However, by dovetailing (on the team's initiative) the concept of design thinking with the framework the TUM: Junge Akademie sets, the team managed to diverge and converge their ideas in an organized fashion. Thus, the students found a way to tame the chaos that can always occur when different backgrounds collide in interdisciplinary projects. The team's committed, cooperative, and goal-oriented way of working was exemplary.

Also remarkable is the product the team has created. MUCtrail does not only impress with its attractive appearance and professional technical implementation. The cooperation with the Department of Environment and Health of the City of Munich ensures that MUCtrail is available to the general public and will continue to exist in the long term. This sustainability sets the project apart from many student initiatives that do not get beyond the pilot stage.

Ambitious, moreover, was the accompanying scientific study the team had planned. With an established tool from the field of education sciences, the students planned to assess MUCtrail in an interventional study with school classes from public schools in Munich. However, this plan was eventually thwarted by the ban on school trips and administrative delays during the COVID-19 pandemic.

Even though the project is incapable of answering the question of whether an approach such as MUCtrail will ultimately lead to scientific evidence being heard more in society, MUCtrail is in any case a welcome initiative. Not only has the project been a gain in experience and skills for the students, but also it created an offering from which both science and society can only benefit! ■

Journalistic part MUCtrail

Have you heard your parents or grandparents talk about how green and calm the city was a few years ago? All the time right!? This is the direct impact of climate change. Climate change is affecting millions worldwide. The rising sea levels, melting of global ice caps, increased variation in temperature across seasons are only some of the numerous other factors negatively impacting the environment.

In this respect, the city of Munich has not been untouched, and its effects are real. The city has expanded with more high-rise buildings than ever before, with technological interventions becoming the norm. Sustainable living practices with a focus on future generations is indeed improving the quality of life. Movements like Fridays for Future started by Greta Thunberg, a Swedish environmental activist, have garnered worldwide support. The youth and children are rallying to take action towards slowing down the detrimental impacts of global warming, dying rivers, and disappearing forests on nature. Inspired by Greta, children in Munich are protesting – by skipping school on Fridays – against inaction and disregard for the harmful impacts of climate change.

Now that we have your attention, we would like to focus on Mia, a young girl curious about science. She is taking a walk around the majestic Olympiapark in the heart of Munich, breathing the fresh air and enjoying the scenic beauty.

She is tired of listening to boring lectures and doing endless assignments on environmental science. She wants to learn about the intrinsic process of science albeit in a playful way.

Forscher Fritz is a climate change researcher. He knows about the scientific method and wants to share his knowledge with the world. He feels that children lack adequate knowledge of the scientific method. Further, he knows that not many children have the privilege and access to learn about research and the process of doing science.

We aim to bring Forscher Fritz and Mia closer together. We want to improve people's attitudes by educating them about the scientific method in the context of climate change. We present to you Munich Urban Climate Trail (MUCtrail), "a playful way to evoke scientific curiosity about climate change."

We developed an online adventure trail with seven stations. Each station depicts a step in the scientific method. We allow Mia to explore the different stations and learn more about the scientific method with quizzes and info-boxes. We conclude with a conversation between Mia and Forscher Fritz. The researcher asks insightful questions about the process of doing science, and Mia answers by applying the knowledge she gained about the scientific method.

MUNICH URBAN CLIMATE TRAIL

And so, the adventure begins! Mia first arrives at the Olympiapark hill and witnesses the tall buildings surrounding the locality. Here she exclaims how hot it is just before the winter. When her mother tells her things were not like this a few years ago, she learns about the concept of urban heat islands. She learns that this phenomenon has an adverse impact on not only the humans but also the animal species dwelling in the region.

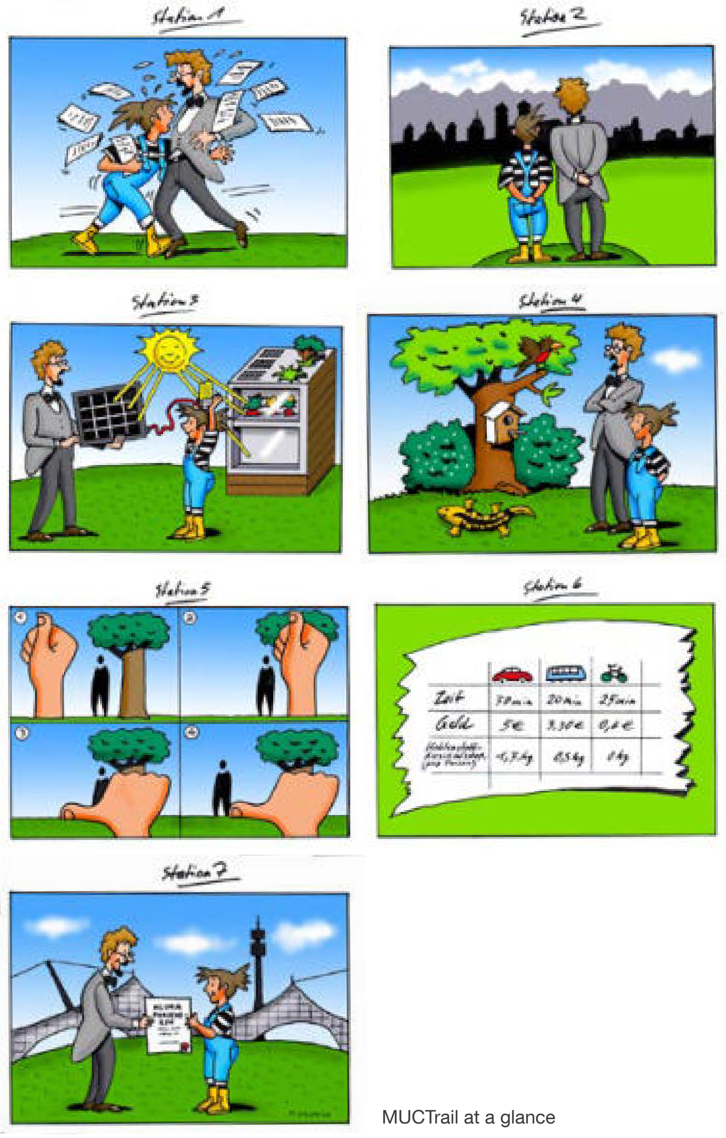
Next, she moves on to learn about green architecture taking into account construction in urban areas. This allows her to observe the environment closely. In the next station, she learns how to formulate scientific assumptions. She does this by learning how she can improve the coexistence of humans and animals in the city. In the Urban Vegetation station, she experiments with determining the tree height. Finally, she learns that it is important to collect data for the experiments to validate her assumptions. She does this in analyzing which transport method is the most eco-friendly in an urban setting like Munich.

In the last station, Mia meets Forscher Fritz to test her learning. Here is an excerpt from the engaging conversation between Mia and Forscher Fritz.

Mia: I think I know much more about the climate in Munich now than I did before! Thank you, Researcher Fritz!
Forscher Fritz: Stop, stop, not so fast! What did you learn about the scientific method?
Mia: Quite a lot. I have to measure and speculate and...
Forscher Fritz: But that's all mixed up! Let's go over it through a quiz.

Researcher Fritz: If I notice, for example, that in summer it is warmer between the houses than here in the park, what do you call that?
Mia: It is called Urban Heat Island. Observation is the first step in the scientific method.
Researcher Fritz: Very good, Mia! For which step of the scientific method is the sentence "I think that the sand lizard seeks stones in the sun to warm itself" an example?
Mia: Ooh, that's a great question. I presume that animals, like humans, experience heat and cold during different seasons. That's probably why the lizard came outside its natural habitat.
Forscher Fritz: Yes, indeed you are absolutely thinking in the right direction. After observation, comes the presumption or hypothesis. Now, do you want to find the height of a tree without using any additional tools?
Mia: I love experimenting. The tree is so much taller than me and has grown bigger than the previous time I was here!
Forscher Fritz: You are so smart, Mia! The next step after observation and hypothesis is setting up experiments. By experimenting, you can collect data for verifying your assumptions.
You are almost there. Last question. You know that there are different modes of transportation in the city. How do we know which is the most climate-friendly option?
Mia: Yes, I do. I compare the carbon-dioxide emissions from cars, buses, trains, and bikes. I always use public transport and ride my bike in the park.
Forscher Fritz: You did it! The evaluation of measured values is the last step of the scientific method by which new knowledge can be gained.
See, it was not so complicated after all!
Mia: Yes, researcher Fritz. Now I know everything about the scientific method and cannot wait to share it with my friends!

Want to be like Mia?
So, what are you waiting for? Grab your phone and head to Olympiapark with an open mind for a journey through MUCtrail – your favorite Munich adventure trail. Experience learning about the scientific method, experience real-world scenarios of climate change in Munich, tickle your brain with interesting puzzles, info-boxes, and much more. Log on to www.muctrail.de and begin an adventure you will never forget!



MUCTrail at a glance

MUCtrail

Table of contents:

Abstract

Background

Goals and Methods

Outcome and Discussion

Initial Evaluation

Discussion

Abstract

There is a need to understand and improve the relationship between science and society. Literature shows that people's knowledge about science, especially that of children, is limited. We hypothesize that this may be due to lack of understanding of the scientific method, leading to a negative attitude towards science. To verify the hypothesis we developed an online adventure trail to educate people about the scientific method in the context of climate change. Our project, Munich Urban Climate Trail (MUCtrail) aims to evoke scientific curiosity in a playful way. We use the design thinking approach to understand the problem, define the target audience, develop our idea, prototype, implement and test it. We develop an online adventure trail in collaboration with the City of Munich's *Referat für Umwelt und Gesundheit* with Olympiapark as the backdrop. Each station in the trail educates and informs the user about different aspects of climate change in urban areas while walking through the different steps of the scientific method. The effectiveness of the online tool is assessed by a questionnaire regarding the scientific method supplied to the participants. We observed that participants showed improved knowledge of the scientific method and climate change in an urban environment like Munich. We therefore conclude that a positive attitude towards science should be fostered to enable a greater scientific knowledge.

Background

According to Tubefilter, 2019, more than 500 hours of video content is uploaded to YouTube every minute worldwide. This translates to 30,000 hours of content per hour and 720,000 hours worth content every day. It would take an individual 82 years i.e. an entire lifetime to watch video content on YouTube uploaded only in one hour. It is therefore evident that the internet has contributed to increased accessibility and affordability of information worldwide.

At the same time, misinformation, fake news and selective consumption of information has clouded people's judgment. Objective information analysis and scientific thinking is key to making informed choices. Literature (Im Dialog, W., & Emnid, K. (2018)) shows that several people feel that they do not understand many things about science and research and that 40% consider they weren't taught well in school how science works.

What is the scientific method?

According to Britannica Encyclopedia 2012, the scientific method is the process of observation, questioning, making predictions, setting up experiments, collecting data and validating the hypothesis. The hypothesis is not fixed but is redefined based on the results of these experiments. This iterative process is continued until consistency between hypothesis, observations and experimental tests is reached. Data collection and analysis is the final part of the scientific method leading to scientific discoveries and scientific insights.

Challenges in science communication

Communication of scientific facts to society is challenging. Low levels of vaccination (Robert Koch-Institut (2018)) and low rate of acceptance of genetically modified food are some of the examples of this challenge. Surveys show that scientific education at school is inefficient in imparting knowledge related to the scientific method and scientific process (Im Dialog, W., & Emnid, K. (2018)). Children from disadvantaged sections and lower socio-economic backgrounds bear a heavier brunt due to ineffective didactic techniques (Pupeter, M. and Wolfert, S. (2018)).

Apart from socio-economic background, several factors influence student's success and performance in science classes. One among them is attitude towards science which comprises motivation towards science, perceived difficulty of science, nature of classroom environment etc. (Osborne, J., Simon, S., & Collins, S. (2003)). Though many pupils inherently like science and are interested in it, there is a negative attitude towards school science. According to a study (Ebenezer, J. V., & Zoller, U. (1993)), 73% of pupils believed that science is important at school, around 40% participants found science classes boring. This shows a 'love-hate' relationship between students and science.

Cognitive load is the quantity of working memory resources, which are put into use. Cognitive load is of three types - intrinsic, extraneous, and germane. Intrinsic cognitive load is the effort related to a particular topic, extraneous cognitive load is the manner of presentation to the learner and germane cognitive load is the work geared towards creating a permanent knowledge trove or a schema. Studies (Sweller, J. (1988)) show that domain specific knowledge in the form of schemas determine problem-solving ability and help distinguish novices from experts. Grasping principles of the scientific method requires high cognitive load. There is therefore a need for intervention to reduce the cognitive load on children.

Hypothesis

Attitude towards science has an impact on success in science classes (Osborne, J., Simon, S., & Collins, S. (2003)). We would like to improve the attitude towards science to contribute positively to the professional life of students. Therefore, we hypothesize:

A lack of understanding of the scientific method leads to a negative attitude towards science.

To test our hypothesis, we believe that educating people, especially children and youth about the scientific method is crucial to improving the attitude towards science. Studies show that imparting scientific knowledge through gamification techniques have proved to improve children's attitude and approach towards science (Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015)). We utilize this approach to improve scientific understanding among pupils in an interactive and visual way.

Goals and Methods

Our vision is to bring science and society closer together. As science encompasses a variety of fields, we scoped our project to a specific area. We chose climate change as it discussed worldwide and is one of the ongoing challenges of mankind. We aim to reshape the thinking about the environmental impacts of climate change and at the same time educate people about the scientific method, which plays a major role in researching climate change.

To achieve these goals, we designed a new adventure trail with the City of Munich's *Referat für Umwelt und Gesundheit*. The adventure trail is modelled on the topic of climate change in urban areas at the Olympiapark in Munich. Our adventure trail can be accessed here https://MUCtrail.de/.

We reached the idea of developing an adventure trail based on the Design Thinking approach (Brown, T. (2008)). The Design Thinking approach has five stages – Empathize, Define, Ideate, Prototype, Test – and we will walk you through the entire process pertaining to our project in this section.

Empathizing with audience

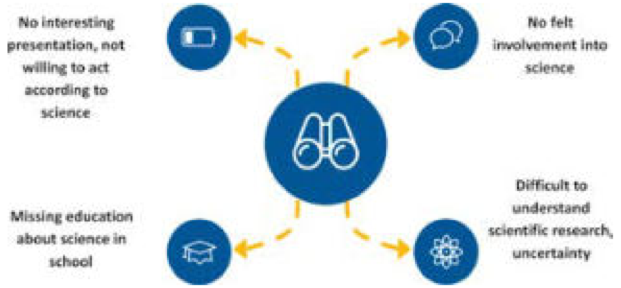

No interesting presentation, not willing to act according to science
No felt involvement into science
Missing education about science in school
Difficult to understand scientific research, uncertainty

Figure 1: Challenges faced by society with respect to science

The empathize phase involves putting ourselves in the shoes of the target audience. In this case, society is our target audience. As a team, we discuss the challenges society faces with regard to science as shown in Figure 1. We took inspiration from relevant literature in the fields of medicine, psychology, strategy, marketing etc. to understand the gaps in science communication to society. We also interviewed more than 10 people from diverse age groups, backgrounds and education levels. We created a questionnaire about perceived challenges between science and society. There were multiple-choice questions as well as the possibility to express opinions in participant's own words. The interviewees expressed that they had not yet been involved in scientific research but were willing to participate in more if provided with the possibility to do so. Some also showed dissatisfaction about the lack of practical teaching while communicating science in school and expressed a need for making the presentation of scientific facts more entertaining and interesting.

Based on our analysis of the literature and interviews, we categorized the main challenges with science communication into three broad areas – education, involvement and communication channel. We developed research questions for each of these three areas. In the area of education, the motivation was to improve understanding of the scientific method in schoolchildren. The second area of involvement was to integrate science better with society. The third aspect was to improve the manner in which science is communicated to society to make it more understandable. The onus was on us to decide our area of interest and how we could maximize the impact of our project.

Project definition

The next step in the Design Thinking process after "Empathize" is "Define". Here we narrow down the scope of our project. The target audience is chosen and the exact problem to be tackled is mentioned here. For our project, we had to choose from the areas of education, involvement and communication channel. After deliberations and discussions, we decided to move forward with the area of education.

We personally had experienced challenges during our formative years of schooling with regard to science communication. We intend to research a better method to facilitate the transmission of knowledge. We decided children between nine to twelve years of age as our target group. As our project evolved, we realized that our adventure trail caters not only to primary school children transitioning to secondary school but also to all school-going children. Our idea is to therefore provide an interactive way to improve the understanding of the scientific method to children using our adventure trail and educate them about climate change.

Project ideation

In Design Thinking, the next step after empathizing with the target group and defining the core problem is to "Ideate". The ideate phase involves creating multiple solutions to the problem at hand and analyzing the solution from different perspectives. After defining the core problem and the target group, we identified competing solutions, which aim to address our problem. As a group, we came up with thirteen ideas to make science more fun and educational at the same time. We voted the five ideas, which best suited our requirements and were in our scope. We deep dived into each of these and analyzed the proposed solutions from multiple angles. Our analysis was based on aspects such as desirability, viability, feasibility, understandability, originality, creativity, measurability and societal impact. The analysis is presented in Table 1.

We finally selected the idea of a science game. It received the highest score among all other ideas. Apart from the numerical value attached to the decision, we received positive affirmation from our tutors for the idea. Further, we attached great personal value to the idea and were able to visualize ourselves working towards making the science game a reality. We refined our research question further and shifted the focus on analyzing the impact of a science game, played in venues outside school in improving the children's understanding of the scientific thinking process concerning climate change.

Sl. No.	Idea	Desirability	Viability	Feasibility	Understandability	Originality	Societal impact	Creativity	Measurability	Final Score
1	Science Candy	5	3	4	5	5	3	3	2	30
2	Science Game	5	5	4	4	3	4	3	3	31
3	Kasperl-theater	2	3	4	4	3	3	3	2	23
4	1$-box	4	3	3	4	2	3	2	3	24
5	Science Hack	3	2	2	3	1	2	1	4	18

Table 1: Idea assessment

Initial prototype

The stage was now set for building a "Prototype" of the science game. The prototype phase involved tinkering with possible product ideas after finalizing the idea. With inputs from all team members, we finalized the elements of our prototype. As shown in Figure 2, the adventure trail would include playful elements and interaction with nature. This would contribute to enhancing the learning experience for children. Experiment-based learning would allow hands-on training and enhance the learning of the scientific method with respect to climate change.

After developing the prototype, we searched for internal and external partners willing to support us. We required expertise on implementing the adventure trail and ideas to make our project sustainable in the long run. We pitched our idea to a forest discovery planner, a museum planner, the manager of *Würm-Erlebnispfad* (City of Munich), the manager of *Walderlebnispfad Freising* among others. The initial idea was to turn a small hut in Freising into an adventure trail. The idea was to revamp the interiors, create small stations to educate visitors about aspects of climate change and make it attractive especially to children. However, creating physical stations at Freising required our presence on-site. This was a deal breaker as we had to dedicate time during the lecture period to university. Working on weekends was not an option due to unavailability of a workforce to build the physical stations. Though the idea was attractive, we let it go and continued exploring other feasible and sustainable options.

As discussed earlier, we wanted to create an adventure trail which would be easily accessible to children, easy to use and sustain in the long term. We therefore finally decided to develop a new online interactive adventure trail for the existing online platform for the City of Munich's *Referat für Umwelt und Gesundheit*.

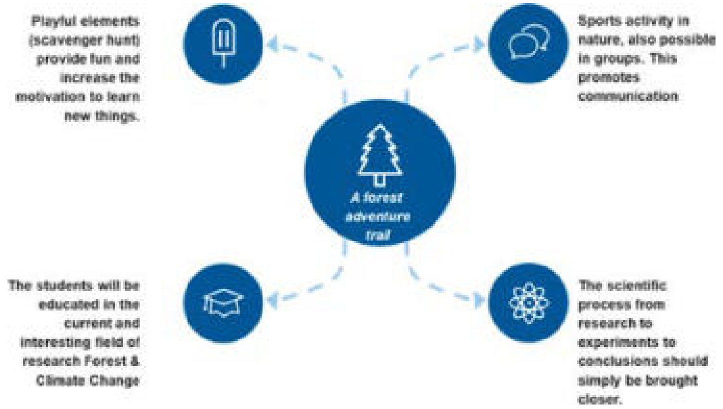

Playful elements (scavenger hunt) provide fun and increase the motivation to learn new things.
Sports activity in nature, also possible in groups. This promotes communication
A forest adventure trail
The students will be educated in the current and interesting field of research Forest & Climate Change
The scientific process from research to experiments to conclusions should simply be brought closer.

Figure 2: Elements in adventure trail prototype

Outcome and Discussion

Run up to station design

As a location the Olympiapark seemed to be the ideal choice, as it is situated close to the city center, well reachable by public transport and often visited by tourists as well as citizens. Furthermore, one has a good view over the city from it's hills and even though this gives it an urban flair you are still in a natural environment, which we deemed important to transport our messages. The duration for completing the trail we set to 30-45 minutes, so the activity would fit well into a family walk and not be considered as too time consuming by many. As our trail features the different stages of the scientific method we wanted 4-6 stations, each focusing on one single aspect of this method as well as a station for introduction and conclusion. Together with our collaborators at the *Referat für Umwelt und Gesundheit*, who wanted the trail not to have a mandatory order, we finally decided on six stations. As each station requires a certain level of interaction with one's environment they are settled in six distinct locations, connected by an interesting walk offering varied views of the park.

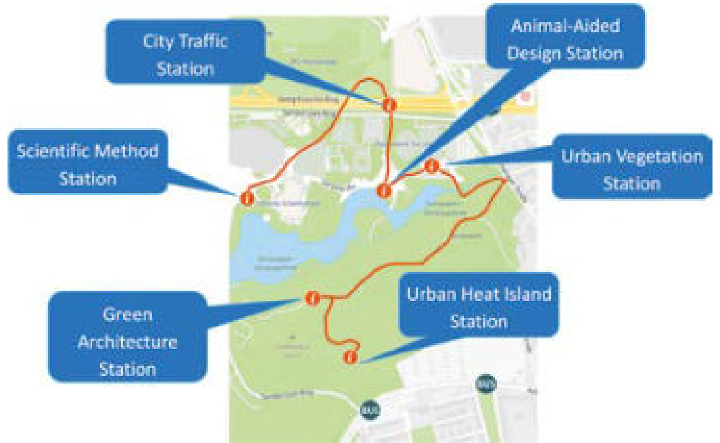

City Traffic Station
Animal-Aided Design Station
Scientific Method Station
Urban Vegetation Station
Urban Heat Island Station
Green Architecture Station

Figure 3: Online MUCtrail in Olympiapark Source: https://MUCtrail.de/

Station Design

To present our content more appealing to children between the age of nine and twelve years, we decided to embed our contents into a story. The protagonists are *Mia* - a girl of about 10 years – and *Forscher Fritz* – a climate researcher. By accident these two meet at Olympiapark and *Forscher Fritz* offers to tell *Mia* more about the climate (change) in Munich and how a scientist conducts his research. Therefore each station is about one specific aspect of urban climate (or another related subject) and one step of the scientific method (s.o.) (Bertemes, J.-P. (2013)). In the following the individual stations are presented.

Urban Heat Islands

The station **"Urban Heat Islands"** is located on the main hill of the Olympiapark, which offers a great view over the city. From here, the participants can observe that the buildings are usually situated quite close to each other. They learn that this influences the urban climate and that a 10°C difference in temperature exists between the city and its surroundings. (Lang, W., Pauleit, S., Brasche, J., Hausladen, G., Maderspacher, J., Schelle, R., & Zölch, T. (2018)). As for the scientific method the station focuses on "literature search" as part of the step "observation".

Green Architecture

The next station **"Green Architecture"** focuses on the different possibilities to render living in the city more friendly to our environment. The participants learn that the use of some isolation materials should be preferred over others (Baunetz_Wissen. Retrieved from https://www.baunetzwissen.de/nachhaltig-bauen/fachwissen/baustoffe--teile/waermedaemmstoffe-682729), and that it is possible to minimize the energy needed for heating by using sustainable sources like the sun (Passivhaus Institut (2015)) Furthermore, this station is about "observation" of one's surroundings as a starting point for further scientific considerations.

Animal-Aided Design

The station **"Animal-Aided Design"** is about the importance of taking the welfare of animals into consideration when designing a city. It portrays the sand lizard and the house sparrow as two examples for animals whose habitat is endangered in human settlements (Hauck, T. E., & Weisser, W. W. (2015)). The participants are being motivated to formulate hypotheses how their survival in urban areas can be facilitated. On the "hypothesis" lies a special focus, as it is one of the steps of the scientific method.

Urban Vegetation

At the station **"Urban Vegetation"** the participants learn that trees worldwide grow faster due to climate change (Pretzsch, H., Biber, P., Schütze, G., Uhl, E., Rötzer, T (2014)). As the station furthermore focuses on the "experiment" as a step of the scientific method, the participants are instructed to conduct their own small experiment. They measure the height of a specific tree without using further material, than their own feet and thumb (Die Sendung mit der Maus. (2018)).

City Traffic

The station **"City Traffic"** is about the contribution of urban traffic to the emission of greenhouse gases. The participants learn that traffic is the main source of carbon dioxide in the city (Weiland, U. (2018)) and that it is therefore of utmost importance to reduce it as well as possible. To compare different means of transport they analyze the data of a fictive experiment by comparing costs, time need and carbon dioxide production (Verkehrsclub Deutschland e.V. (VCD). (2010)). This "Analysis of data" is the conclusive step of the scientific method.

The Scientific Method

The synoptic station **"The Scientific Method"** presents a short overview of all the research steps explained at the different stations on the trail (Bertemes,J.-P. (2013)), which are also displayed in figure 4. It also puts them into a comprehensive sequence, as the trail has no mandatory order. In a short quiz, the participants can repeat all they have learned about urban climate and the scientific method, which can help them to memorize it later.

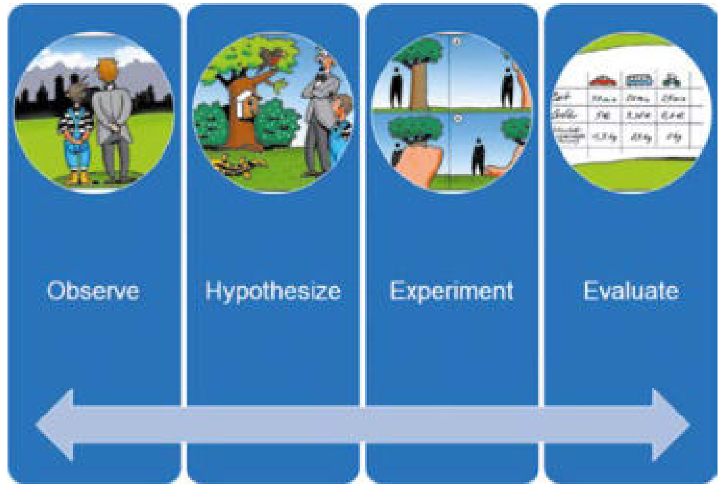


Figure 4: Scientific Method

Initial Evaluation

Methodology

We tested the validity of our trail through an online survey conducted in the German language. Our original plans for a quasi-experimental survey design with students had to be canceled due to the COVID-19 pandemic. In particular, we asked participants to indicate on five-point Likert scales (1 = fully agree, 5 = fully disagree) to what extent they agreed with selected statements. The statements were: "I found the MUCtrail entertaining."; "I learned something about the scientific method."; "I learned something about urban climate."; "I like the graphic design of the MUCtrail."; "The texts are written in a way I can understand. "I found the selection of topics interesting."; "I am interested in further educational trails in Munich." Participants were recruited through our contacts and were instructed to browse through the trail app before filling out the survey.

Results

In total, 12 participants filled out the survey completely. The average age of the participants was 23.83 years, 58.33% were female and 91.67% had a university degree. The survey results are visualized in Figure 5 to Figure 11. In particular, all participants agreed or fully agreed that the MUCtrail was entertaining. Furthermore, a total of 12 and 9 participants agreed or fully agreed respectively with the statements saying that they learned something about scientific work and urban climate. Finally, 11 participants agreed or fully agreed with the statements, that the texts were easy to understand and that the selection of topics was interesting. However, when it came to the interest in further educational trails, the participant expressed a more differentiated opinion. Only seven participants agreed or fully agreed with the statement that they would be interested in further educational trails in Munich. In the free feedback section of the survey, some participants praised the trail (e.g., "Very well done, I enjoyed it!"). Other participants pointed out some graphical and spelling mistakes and provided advice for the further development of the trail (e.g. additional audio files).

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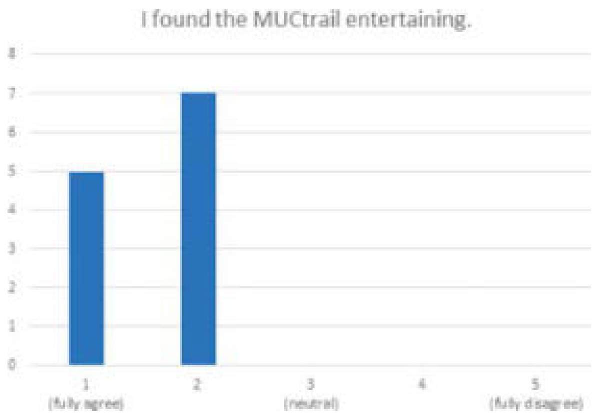

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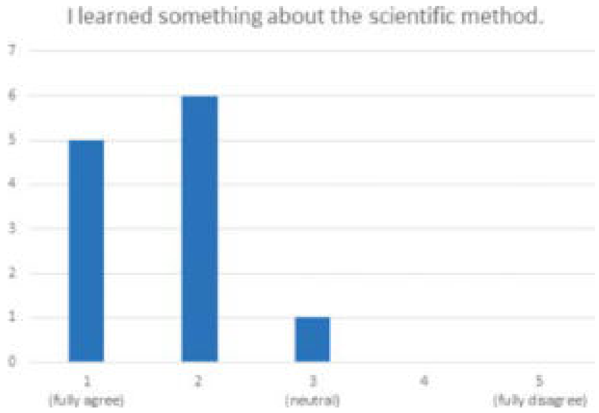

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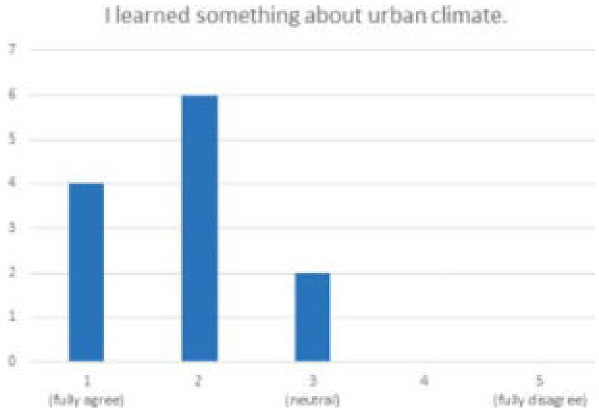

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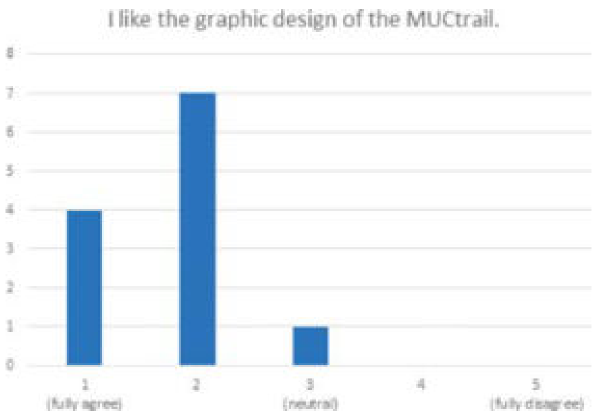

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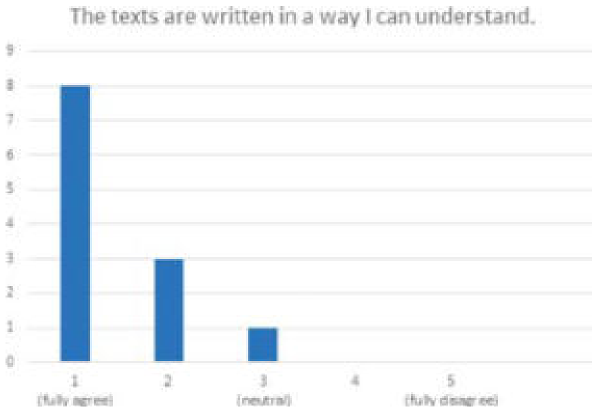

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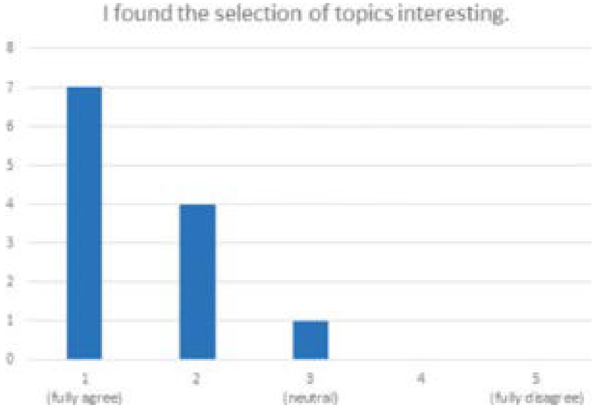

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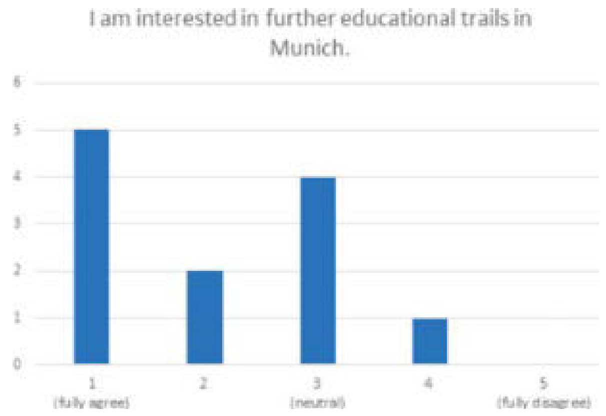


Figure 5 to Figure 11: Questionnaire response results

Discussion

Summary and Future Goals

Based on user feedback of MUCtrail, we have been successful in our goal of bringing awareness of climate change and the scientific method to people in a playful way. More than 90% of the participants found MUCtrail interesting and entertaining. More importantly, on an average, 87.5% of the respondents learnt about the scientific method in the context of urban climate. The interactive interface and graphic design made a positive impact on more than 90% of the MUCtrail users. Due to time constraints and resource limitations as a result of COVID-19, we were only able to achieve limited participation in the MUCtrail. The 12 participants had a university degree and were known to us personally.

In the future, we aim to survey a larger user sample with a more diverse educational and socio-economic background. The focus will be on students between nine to twelve years, which is our target group. This will help us gain more insight into the impact of MUCtrail on a larger scale and gauge the improvement in knowledge of the scientific method holistically. Furthermore, the design of the survey does not allow for causal conclusions, so experimental survey designs are promising research opportunities. Currently, the website is available only in German. We aim to make the website available in English as well. This will allow greater access to MUCtrail and increase awareness of science, scientific method and climate change worldwide. ■

References

- Im Dialog, W., & Emnid, K. (2018). Wissenschaftsbarometer 2018. Berlin, www.wissen schaft-im-dialog.de/fileadmin/user_upload/Projekte/Wissenschaftsbarometer/Dokumente_17/WB_2017_Web. pdf, letzter Aufruf, 20.
- https://www.britannica.com/science/scientific-method
- Robert Koch-Institut (2018): Impfquoten bei der Schuleingangsuntersuchung in Deutschland 2016. Epid Bull 2018;16:151 – 156 | DOI 10.17886/EpiBull-2018-020
- Pupeter, M. and Wolfert, S. (2018): Schule: Frühe Weichenstellungen, in Andresen, S., Neumann, S., and Kantar Public (eds) (2018): Kinder in Deutschland 2018 – 4. World Vision Kinderstudie. 1st edn. Weinheim: Beltz, pp. 76–78.
- Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. International journal of science education, 25(9), 1049-1079.
- Ebenezer, J. V., & Zoller, U. (1993). Grade 10 students' perceptions of and attitudes toward science teaching and school science. Journal of Research in Science teaching, 30 (2), 175-186.
- Sweller, J. (1988). Cognitive Load During Problem Solving: Effects on Learning. Cognitive Science, 12, 257-285.
- Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: A systematic mapping study. Journal of Educational Technology & Society, 18 (3).
- Brown, T. (2008). Design thinking. Harvard business review, 86 (6), 84.
- Lang, W., Pauleit, S., Brasche, J., Hausladen, G., Maderspacher, J., Schelle, R., & Zölch, T. (2018). Leitfaden für klimaorientierte Kommunen in Bayern. Handlungsempfehlungen aus dem Projekt Klimaschutz und grüne Infrastruktur in der Stadt am Zentrum Stadtnatur und Klimaanpassung.
- https://www.baunetzwissen.de/nachhaltig-bauen/fachwissen/baustoffe--teile/waermedaemmstoffe-682729
- https://passiv.de/de/02_informationen/01_wasistpassivhaus/01_wasistpassivhaus.htm
- Hauck, T. E., & Weisser, W. W. (2015). AAD Animal-Aided Design.
- Pretzsch, H., Biber, P., Schütze, G., Uhl, E., Rötzer, T.: Forest stand growth dynamics in Central Europe have accelerated since 1870. Nature Communications 5/ 2014.
- Die Sendung mit der Maus. (2018). Internet-Sachgeschichte: Baumhöhe messen. Das Erste. https://kinder.wdr.de/tv/die-sendung-mit-der-maus/av/video-internet-sachgeschichte-baumhoehe-messen-100.html
- Weiland, U. (2018). Stadt im Klimawandel. Bundeszentrale für politische Bildung. https://www.bpb.de/politik/innenpolitik/stadt-und-gesellschaft/216883/stadt-im-klimawandel?p=all#footnode8-9
- Verkehrsclub Deutschland e.V. (VCD). (2010). Klimabewusst unterwegs: Verkehrsmittel im Umwelt-, Zeit- und Kostenvergleich. Verbraucherzentrale Bundesverband e. V. https://www.verbraucherzentrale-bayern.de/sites/default/files/migration_files/media221043A.pdf
- Bertemes,J.-P. (2013). Was ist die wissenschaftliche Methode?. https://www.science.lu/de/wie-forscher-arbeiten/was-ist-die-wissenschaftliche-methode
- Passivhaus Institut (2015). Retreived from https://passiv.de/de/02_informationen/01_wasistpassivhaus/01_wasistpassivhaus.htm
- Baunetz_Wissen. Retreived from https://www.baunetzwissen.de/nachhaltig-bauen/fachwissen/baustoffe--teile/waermedaemmstoffe-682729

Self Reflection

At the Kick-Off event at Lake Starnberg the group of people interested in doing research about the interaction of science and society split into half and formed two teams, one of them being our team Munich Urban Climate Trail which was at that time called “Scienciety”. Unfortunately this first split wasn’t the last one our group experienced – in the first few months we had three members leaving the team for various reasons and one joining it. Though these changes made structured and productive working hard at first we could already settle on our target group – school aged children – and on communicating how science works as a goal. After our final team, consisting of Niklas Dreymann, Johaina Kullab, Nitish Nagesh, Beate Neu and Jessica Neusser, formed we could more intensively focus on developing an idea using the Design Thinking Methode as a guideline. In retrospect this was the most creative time of the whole journey and we had some pretty intense working phases, such as a Bootcamp at Niklas’ hometown Bad Sachsa, where we decided to create a science game as a final product. During this phase of generating new ideas, it was due to Niklas’ careful planning of our meetings and his overseeing our progress on our individual tasks, that we didn’t get lost in indecision. Johaina and Jessica did a great job in reaching out to potential collaborators, Nitish was taking good care of our posts and Beate elaborated the scientific background of the project. But as often in life inspiration didn’t come through great effort but in the form of a conversation with another teams’ member on the way home, who mentioned that he had always had great fun in learning stuff doing interactive adventure trails. Though this idea wasn’t completely new to us, this conversation facilitated our decision to pursue it, and after we made that call all the other tasks fell in place: in a natural environment of course the topic climate change would fit perfectly and for realising an adventure trail there weren’t too many potential collaborators. Afterwards there was a bit of exhaustion noticeable in the team – we had the feeling to be through the roughest stretch but the most of work for conceptualising and realising the actual trail was yet to be done. Most fortunately we won the Referat für Umwelt as a collaborator who could set us up with an existing platform for creating our trail in form of a Web-App. To elaborate the content of the trail each team member was focussing on a different topic. This was necessary to gain enough expertise, but slowed our working progress also significantly down because we were focusing more on ourselves than motivating each other. And even after we had a better idea on what each station should look like it took us more time than anticipated to find a designer to draw some sketches for us and someone to read our text for final corrections. Being so focussed on the trail itself we neglected the scientific side a bit. It had always been the greatest challenge for us, as none of us had much knowledge of how research in social sciences is properly conducted and it was therefore more than obvious that it was not our area to shine. In March 2020 the Coronavirus pandemic imposed a further threat on our research as it became clear that in the close future there would be no opportunity to have pupils participate in our trail and measure the impact it had on them as we formerly planned to do. Very recently the measures to prevent the spread struck us again when the event to present our trail to the public was postponed to spring 2021 (safety first!). The last couple weeks of the program felt like the last miles of a marathon – we had to add some final touches but our minds were already dealing with new and exciting developments in our lives. Now that we look back on our time in TUM: Junge Akademie we remember the personal effort it cost each of us, are proud of our achievements and genuinely happy to have stepped up to the challenge.

Acknowledgement

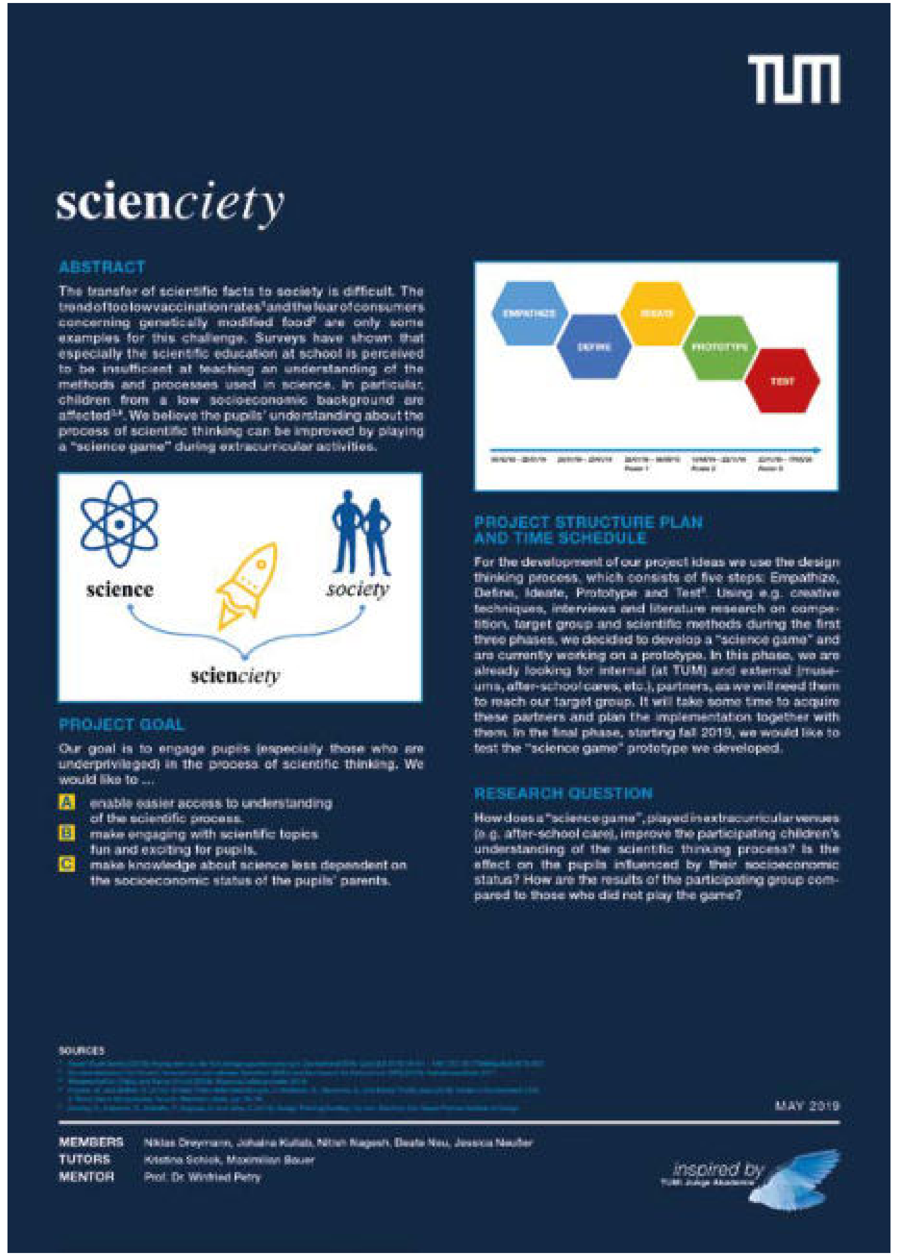
We would like to thank all the members of the TUM: Junge Akademie family for this enriching experience. We thank Prof. Müller for his vision and inspiration during the entire program. Peter Finger supported us during the whole journey from the start till the end, always patient and energetic. Maria Hannecker was the sweetest person we could talk to and she was always ready with her enthusiasm to help us during the workshops, seminars and individual discussions.

Our tutors, Kristina Schick and Maximillian Bauer, were supportive and encouraged us to think outside the box. Their inputs helped us implement the project better and in a more scientific way. Prof. Petry, our supervisor, encouraged us to think scientifically and provided the initial direction required for our long term project. We thank the lovely Junge Akademie office assistants for maintaining constant communication and ensuring timely submission of posters, reports and milestone progress.

We immensely benefited from the scientific writing workshop provided by Dr. Weitze along with constant updates regarding the project report form Constanze. During this 22-month long journey, the workshops conducted were the most exciting and enriching. We thank Dr. Alexander Lang, Matthias Lerner, Stefan Röhrl for their insights on project management. Elizabeth Raes and her colleague helped us in developing our team canvas to stay on track and together during the project duration. We also thank members of the different taskforces, especially Events, for organizing visits to museums, ballets, operas along with the running dinner and photography sessions.

Our collaborators at the *Referat für Umwelt* we genuinely thank for providing the perfect platform to launch our trail and their expertise and flexibility in realising it. We are especially grateful to Moritz Monninger and Franziska Naumann who we could always approach with our suggestions. We would also like to thank Isabel Boergen for correcting the text for the Web-App and making it more suitable and fun to read for children. The designers, Ulrich Leyermann and Reiner Stolte, breathed life into our graphics, posters and the Web-App allowing enhanced visual appearance and aesthetics.

We thank our friends and family for answering questionnaires, providing useful inputs regarding existing gaps in science communication and supporting us throughout this wonderful journey. We apologize if your name is not mentioned here and you have interacted with us in any way. We remember you in our hearts and dedicate this to all of you and to the society for the betterment of science. ■



TUM

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ABSTRACT

The transfer of scientific facts to society is difficult. The trend of too low vaccination rates[1] and the fear of consumers concerning genetically modified food[2] are only some examples for this challenge. Surveys have shown that especially the scientific education at school is perceived to be insufficient at teaching an understanding of the methods and processes used in science. In particular, children from a low socioeconomic background are affected[3,4]. We believe the pupils' understanding about the process of scientific thinking can be improved by playing a "science game" during extracurricular activities.

PROJECT GOAL

Our goal is to engage pupils (especially those who are underprivileged) in the process of scientific thinking. We would like to ...

- A enable easier access to understanding of the scientific process.
- B make engaging with scientific topics fun and exciting for pupils.
- C make knowledge about science less dependent on the socioeconomic status of the pupils' parents.

PROJECT STRUCTURE PLAN AND TIME SCHEDULE

For the development of our project ideas we use the design thinking process, which consists of five steps: Empathize, Define, Ideate, Prototype and Test[5]. Using e.g. creative techniques, interviews and literature research on competition, target group and scientific methods during the first three phases, we decided to develop a "science game" and are currently working on a prototype. In this phase, we are already looking for internal (at TUM) and external (museums, after-school cares, etc.), partners, as we will need them to reach our target group. It will take some time to acquire these partners and plan the implementation together with them. In the final phase, starting fall 2019, we would like to test the "science game" prototype we developed.

RESEARCH QUESTION

How does a "science game", played in extracurricular venues (e.g. after-school care), improve the participating children's understanding of the scientific thinking process? Is the effect on the pupils influenced by their socioeconomic status? How are the results of the participating group compared to those who did not play the game?

SOURCES

MAY 2019

MEMBERS Niklas Dreymann, Johanna Kullab, Nitish Nagesh, Beate Neu, Jessica Neußer
TUTORS Kristina Schick, Maximilian Bauer
MENTOR Prof. Dr. Winfried Petry

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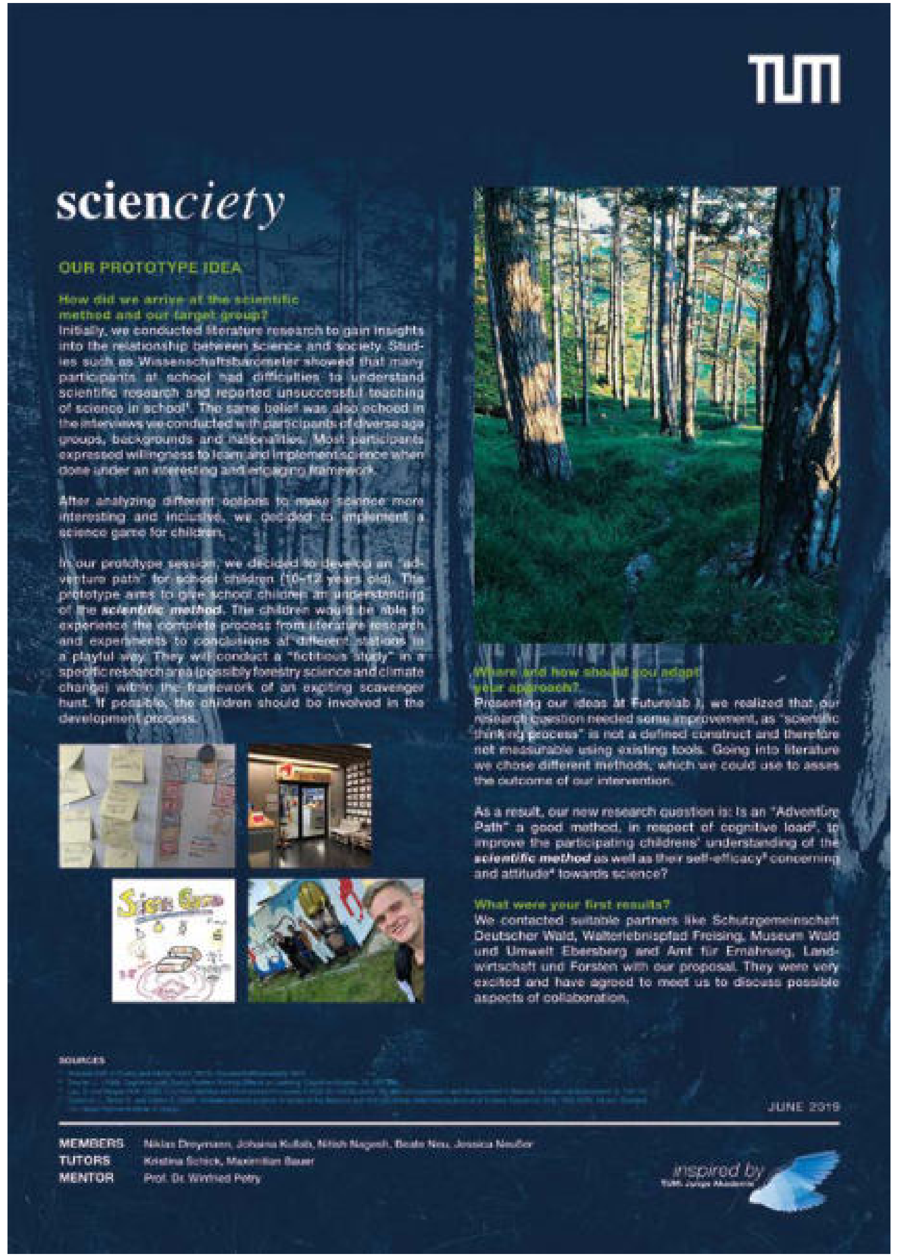
TUM: Junge Akademie

POSTER 1: We had our first kick-off at Generali Academy near Lake Starnberg in November 2019. We chose our teams and topics. We as a team decided to work on bringing science and society closer to each other and called ourselves "Sciencity." Armed with project management tools from the workshops conducted at Generali Academy and Bad Tölz, we developed a project structure plan and time schedule. We adopted a design thinking approach with the following phases – Empathize, Define, Ideate, Prototype, and Test. We then developed our initial hypothesis and set our project goals. The main goal was to enable an easier understanding of the scientific process, especially among pupils. We then conducted a literature review and developed our initial research question. We then communicated our findings at a workshop in Haus der bayerischen Landwirtschaft, Herrsching. ■



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OUR PROTOTYPE IDEA

How did we arrive at the scientific method and our target group?

Initially, we conducted literature research to gain insights into the relationship between science and society. Studies such as Wissenschaftsbarometer showed that many participants at school had difficulties to understand scientific research and reported unsuccessful teaching of science in school[1]. The same belief was also echoed in the interviews we conducted with participants of diverse age groups, backgrounds and nationalities. Most participants expressed willingness to learn and implement science when done under an interesting and engaging framework.

After analyzing different options to make science more interesting and inclusive, we decided to implement a science game for children.

In our prototype session, we decided to develop an "adventure path" for school children (10–12 years old). The prototype aims to give school children an understanding of the **scientific method**. The children would be able to experience the complete process from literature research and experiments to conclusions at different stations in a playful way. They will conduct a "fictitious study" in a specific research area (possibly forestry science and climate change) within the framework of an exciting scavenger hunt. If possible, the children should be involved in the development process.

Where and how should you adapt your approach?

Presenting our ideas at Futurelab I, we realized that our research question needed some improvement, as "scientific thinking process" is not a defined construct and therefore not measurable using existing tools. Going into literature we chose different methods, which we could use to assess the outcome of our intervention.

As a result, our new research question is: Is an "Adventure Path" a good method, in respect of cognitive load[2], to improve the participating childrens' understanding of the ***scientific method*** as well as their self-efficacy[3] concerning and attitude[4] towards science?

What were your first results?

We contacted suitable partners like Schutzgemeinschaft Deutscher Wald, Walderlebnispfad Freising, Museum Wald und Umwelt Ebersberg and Amt für Ernährung, Landwirtschaft und Forsten with our proposal. They were very excited and have agreed to meet us to discuss possible aspects of collaboration.

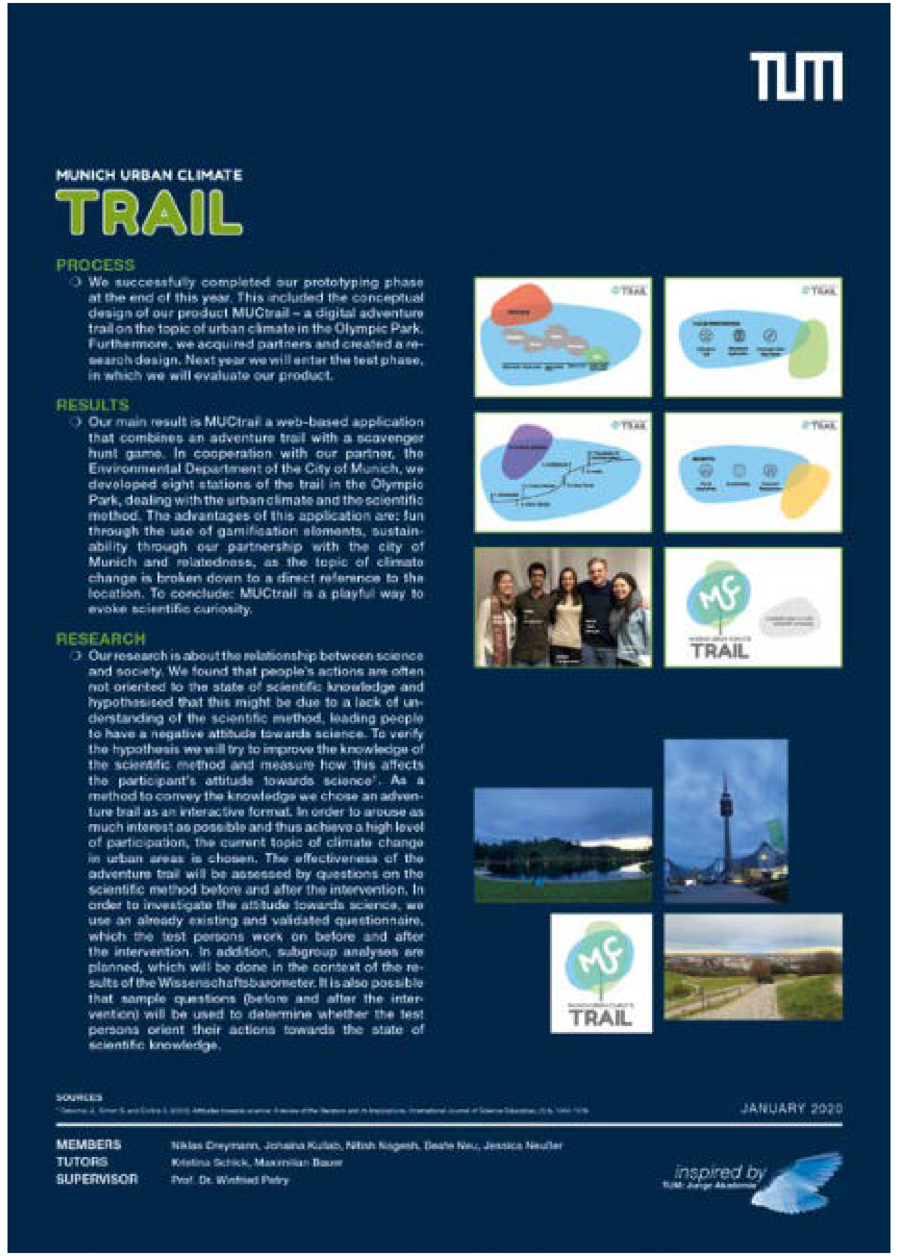
SOURCES

JUNE 2019

MEMBERS Niklas Dreymann, Johanna Kullab, Nitish Nagesh, Beate Neu, Jessica Neußer
TUTORS Kristina Schick, Maximilian Bauer
MENTOR Prof. Dr. Winfried Petry

inspired by
TUM: Junge Akademie

POSTER 2: After communicating our hypothesis and research question, we gained an insight into science communication and ethics in science at a workshop conducted in Haus der bayerischen Landwirtschaft, Herrsching. With more project management inputs at our disposal, we moved forward in our design thinking phase towards creating a prototype. We decided to develop a science game for schoolchildren to help them learn more about the scientific method. We wanted it to be a fun and interactive learning experience. We tinkered with various prototypes at the TUM Makerspace at Garching. Finally, we zeroed in on creating an adventure trail to educate children about climate change in Munich. We contacted many partners, including Deutsches Museum, Munich's environmental department, and an adventure trail in Freising. Based on factors such as sustainability, long-term impact, and resource efficiency, we partnered with the City of Munich's environment department to create a new adventure trail to educate children about the scientific method. ■



MUNICH URBAN CLIMATE
TRAIL

PROCESS

- We successfully completed our prototyping phase at the end of this year. This included the conceptual design of our product MUCtrail – a digital adventure trail on the topic of urban climate in the Olympic Park. Furthermore, we acquired partners and created a research design. Next year we will enter the test phase, in which we will evaluate our product.

RESULTS

- Our main result is MUCtrail a web-based application that combines an adventure trail with a scavenger hunt game. In cooperation with our partner, the Environmental Department of the City of Munich, we developed eight stations of the trail in the Olympic Park, dealing with the urban climate and the scientific method. The advantages of this application are: fun through the use of gamification elements, sustainability through our partnership with the city of Munich and relatedness, as the topic of climate change is broken down to a direct reference to the location. To conclude: MUCtrail is a playful way to evoke scientific curiosity.

RESEARCH

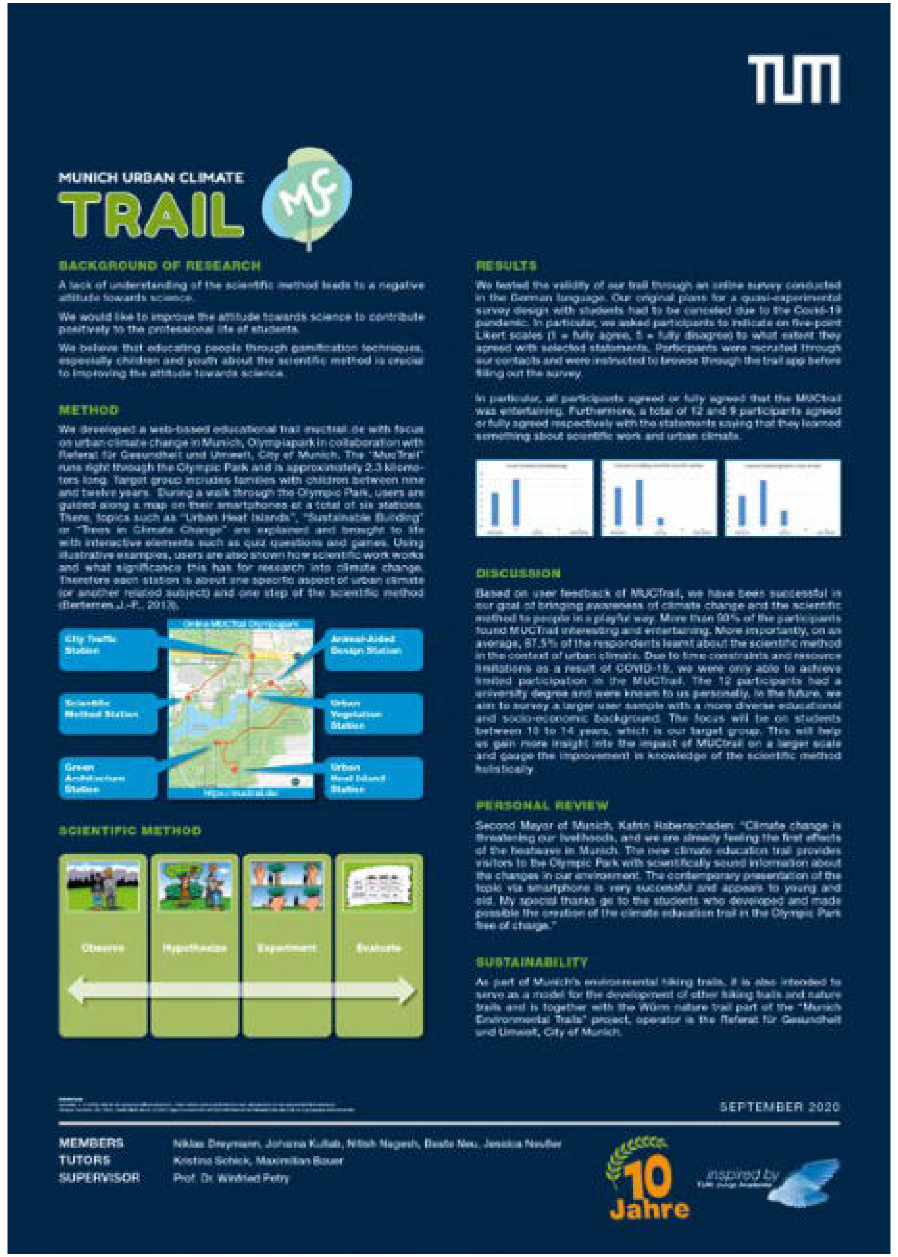
- Our research is about the relationship between science and society. We found that people's actions are often not oriented to the state of scientific knowledge and hypothesised that this might be due to a lack of understanding of the scientific method, leading people to have a negative attitude towards science. To verify the hypothesis we will try to improve the knowledge of the scientific method and measure how this affects the participant's attitude towards science[1]. As a method to convey the knowledge we chose an adventure trail as an interactive format. In order to arouse as much interest as possible and thus achieve a high level of participation, the current topic of climate change in urban areas is chosen. The effectiveness of the adventure trail will be assessed by questions on the scientific method before and after the intervention. In order to investigate the attitude towards science, we use an already existing and validated questionnaire, which the test persons work on before and after the intervention. In addition, subgroup analyses are planned, which will be done in the context of the results of the Wissenschaftsbarometer. It is also possible that sample questions (before and after the intervention) will be used to determine whether the test persons orient their actions towards the state of scientific knowledge.

SOURCES

JANUARY 2020

MEMBERS Niklas Dreymann, Johanna Kullab, Nitish Nagesh, Beate Neu, Jessica Neußer
TUTORS Kristina Schick, Maximilian Bauer
SUPERVISOR Prof. Dr. Winfried Petry

POSTER 3: Based on our evolved aims and goals, we renamed ourselves Team MUCTrail (Munich Urban Climate Trail) in the workshop held at the Akademie Schönbrunn in Gut Häusern. We incorporated the principles of good research practices taught at Vollmar Akademie, Kochel am See into our project. After creating the initial prototype, we finalized our project as an attempt to promote scientific curiosity in a playful way. We designed a digital adventure trail based on urban climate in Olympiapark in partnership with Munich's environmental department. We developed six stations to educate children about the scientific method. The scientific method comprises observation, followed by hypothesis, then testing the hypothesis with experiments, and finally analyzing the data obtained. The stations are designed to inform users about a number of different aspects related to the urban climate. They include urban heat islands, urban architecture, inter-relationships between man and animal, urban traffic, and urban vegetation. At each station, there is an explanation of the phenomenon followed by quizzes to develop critical thinking in children and educate them about the changing environment dynamic in Munich. The last station summarizes the entire trail and teases the brain with insightful questions about the scientific method. ■


TUM
Online MUCTrail Olympiapark
City Traffic Station
Animal-Aided Design Station
Scientific Method Station
Urban Vegetation Station
Green Architecture Station
Urban Heat Island Station
https://muctrail.de
Observe
Hypothesize
Experiment
Evaluate

MUNICH URBAN CLIMATE
TRAIL

BACKGROUND OF RESEARCH

A lack of understanding of the scientific method leads to a negative attitude towards science.

We would like to improve the attitude towards science to contribute positively to the professional life of students.

We believe that educating people through gamification techniques, especially children and youth about the scientific method is crucial to improving the attitude towards science.

METHOD

We developed a web-based educational trail muctrail.de with focus on urban climate change in Munich, Olympiapark in collaboration with Referat für Gesundheit und Umwelt, City of Munich. The "MucTrail" runs right through the Olympic Park and is approximately 2.3 kilometers long. Target group includes families with children between nine and twelve years. During a walk through the Olympic Park, users are guided along a map on their smartphones at a total of six stations. There, topics such as "Urban Heat Islands", "Sustainable Building" or "Trees in Climate Change" are explained and brought to life with interactive elements such as quiz questions and games. Using illustrative examples, users are also shown how scientific work works and what significance this has for research into climate change. Therefore each station is about one specific aspect of urban climate (or another related subject) and one step of the scientific method (Bertemes J.-F., 2013).

SCIENTIFIC METHOD

RESULTS

We tested the validity of our trail through an online survey conducted in the German language. Our original plans for a quasi-experimental survey design with students had to be canceled due to the Covid-19 pandemic. In particular, we asked participants to indicate on five-point Likert scales (1 = fully agree, 5 = fully disagree) to what extent they agreed with selected statements. Participants were recruited through our contacts and were instructed to browse through the trail app before filling out the survey.

In particular, all participants agreed or fully agreed that the MUCtrail was entertaining. Furthermore, a total of 12 and 9 participants agreed or fully agreed respectively with the statements saying that they learned something about scientific work and urban climate.

DISCUSSION

Based on user feedback of MUCTrail, we have been successful in our goal of bringing awareness of climate change and the scientific method to people in a playful way. More than 90% of the participants found MUCTrail interesting and entertaining. More importantly, on an average, 87.5% of the respondents learnt about the scientific method in the context of urban climate. Due to time constraints and resource limitations as a result of COVID-19, we were only able to achieve limited participation in the MUCTrail. The 12 participants had a university degree and were known to us personally. In the future, we aim to survey a larger user sample with a more diverse educational and socio-economic background. The focus will be on students between 10 to 14 years, which is our target group. This will help us gain more insight into the impact of MUCtrail on a larger scale and gauge the improvement in knowledge of the scientific method holistically.

PERSONAL REVIEW

Second Mayor of Munich, Katrin Habenschaden: "Climate change is threatening our livelihoods, and we are already feeling the first effects of the heatwave in Munich. The new climate education trail provides visitors to the Olympic Park with scientifically sound information about the changes in our environment. The contemporary presentation of the topic via smartphone is very successful and appeals to young and old. My special thanks go to the students who developed and made possible the creation of the climate education trail in the Olympic Park free of charge."

SUSTAINABILITY

As part of Munich's environmental hiking trails, it is also intended to serve as a model for the development of other hiking trails and nature trails and is together with the Würm nature trail part of the "Munich Environmental Trails" project, operator is the Referat für Gesundheit und Umwelt, City of Munich.

SEPTEMBER 2020

MEMBERS Niklas Dreymann, Johanna Kullab, Nitish Nagesh, Beate Neu, Jessica Neußer
TUTORS Kristina Schick, Maximilian Bauer
SUPERVISOR Prof. Dr. Winfried Petry

POSTER 4: As COVID-19 struck, our discussions moved online, and the final presentation was delayed. But with our indomitable spirit, we continued marching forward to create an adventure trail accessible to all. After designing the stations, we partnered with a graphic designer, Ulrich Leyermann and Reiner Stolte, to bring our stations and logos to life. We aided Franziska Neumann in creating the muctrail.de website. The website walks users through the different stations while educating them about the scientific method. The trail serves as a tool to improve the attitude of children towards science. Our project accomplishes "multimodal communication," which was the theme of our project year, in a fun and interactive way.

Our adventure trail was inaugurated on September 25, 2020, by Katrin Habenschaden (second mayor of Munich, Bündnis90/Die Grünen) and Prof. Dr. Gerhard Müller (TUM) at Olympiapark. We sent questionnaires to children and assessed their knowledge about the scientific method before and after using our online adventure trail. We noticed that both children and parents were now more aware of the harmful impact of climate change. They were more informed about the scientific method and vowed to take steps to reduce their carbon footprint in Munich and around the world. ■

Quintessence

Project Report **Quintessence**

Team	Daniel Frey Dennis Huber Jonas Papazoglou-Hennig Saskia Hutschenreiter Simon Gandorfer Sophia Hasbach
Tutor	Sebastian Kaltenbach
Supervisors	Prof. Dr. Hans Förstl Dr. Susanne Witzgall

Preface by the Supervisors 160
Journalistic part 162
Scientific part 164
Self reflection 172
Posters 174

Preface by Supervisor

Prof. Dr. Hans Förstl

Caged hunters, bored gatherers

During the pre-COVID era, lectures and seminars represented highly ritualized live gatherings of staff and students celebrating the spirit of science. Nowadays such academic communication is virtually restricted to exchanges in *effigie et verbo absque praesentia*. This is convenient, but a lot of the traditional exercise is lost, including the effort to get up on time, find the way to the lecture rooms, encounter charismatic teachers, meet fellow students in real, have lunch at a given time etc.. Therefore this is a project for both, ongoing studies on-line and the post-COVID period.

Attention has a fast and a hard part. Sharp focusing requires alertness and offers sparks of immediate insight; it is for the genius in ourselves and not always up to the task of an immediate hit right on target. You get the picture (or not). Concentration is for everyone; it is the laborious sustained effort to keep track of content, gather as much information as possible, an effort always bordering on boredom. The text and the reasoning behind the text are studied, and again, and once more if necessary (*repetitio mater studiorum*).

Spirit, “Geist” is fickle and fidgety and notoriously hard to pin down. A domesticated and trained mind may pretend to follow somebody else’s cognitive dance steps for more than a minute or two, the body may sit still on chairs offering limited comfort, eyes and thoughts however will wander vaguely and find consolation in blissful memories and perspectives … whilst authoritative deliberations have long escaped the idle listener.

Attention has to be paid and energy costs are high. Therefore it is of utmost physiological and ecological importance to invest wisely and in harmony with human nature. Astute academic assemblies most modestly make every attempt to deny their very needs, but they respond all the more gratefully if nudged towards invigorating physical exercise, ventilating their strained brains and reinstating fresh supplies of blood, oxygen, glucose, acetylcholine, alertness and stamina.

This study has successfully set out to explore the effects of short intermissions with physical exercise during ninety-minute lectures on subjectively perceived attention. Its results deserve to be considered by students and professors spending long hours in their home offices and also when returning to their traditional chores at a real-world university environment.

Preface by Supervisor

Dr. Susanne Witzgall

The Struggle for Attention

Our globalized and networked world is flooded by information and images fighting for our attention. Social media platforms are equipped with a special design to foster the constant posting, liking or sharing of content in order to catch one’s eye and to increase one’s dwelling time. Personalized ads try to allure us and to draw our interest. Attention is perpetually courted and compelled. It has become one of the most important resources and main commodities in contemporary semio-capitalism (Bifo Berardi), which is mainly based on cognitive rather than material labor.

Against this backdrop the project Quintessence which has set itself the goal to improve the individually perceived attentiveness during university lectures, may arouse suspicion in participating in this current fight for a resource becoming seemingly scarcer every day. However, the means employed by this project were rather short intermissions supposed to provide a temporary release from the constant demand for concentration and productive processing of information. Quintessence created a caesura, an abrupt pause in the rhythmic and abundant flows of words, images and data. Its research findings remind us that there are time-based limits in applying the mind to something and that respecting these neurocognitive limitations could help to create a more fruitful learning atmosphere. In this context we should also never forget that sometimes the best ideas of artists and scientists alike surface while the mind is in a diffuse mode of non-focusing, a condition of distracted attention.

The Quintessential Break

Attention is a quintessential ingredient for successful university lectures. But is the classic format at the Technical University Munich (TUM) doing it justice? A simple tweak may offer profound benefits.

The time is just about 7.45 in the morning, as you leave the house and make your way to the U-Bahn station. You are still tired from yesterday, either from studying, finishing up some work you had left to the last minute to do, or from having gone out with friends. But you knew that you had an 8.30 lecture. In any case, you need to rally. You might get an espresso from a bakery on the way to the train, hoping that this puts you out of your sleepy, wish-you-were-back-in-bed state. You finally enter the train, along with the rest of Munich, and, standing squashed inside a mass of people like a tightly filled can of sardines, you are finally on your way.

Almost every student in their studies at TUM has most certainly experienced the feeling of anticipating a below par lecture, perhaps even on a regular basis. During the last twenty months, team Quintessence, a research group formed by six scholars of the TUM: Junge Akademie (Daniel Frey, Simon Gandorfer, Sophia Hasbach, Dennis Huber, Saskia Hutschenreiter, Jonas Papazoglou-Hennig: Year 2019), have undertaken a project to further understand the causes associated with this important issue regarding the classical teaching format at university. Their aim: to develop simple but effective adjustments to the end of improving the lecture experience. You arrive at the main campus of TUM, where you find that you need to hurry if you do not want to miss the beginning of the lecture, because even though the trip from your home to here should never have taken longer than forty-five minutes, today of course it did. Checking your timetable once more, you assure yourself that you are indeed going the right way, to the Carl von Linde lecture theater. As you arrive in the corridor leading up to the hall, you can already hear the distinctive bang of the entrance door as it opens and shuts when people enter, each bang piercing your tired brain through your ears. The lecture has not yet started. You scout the hall for your friends, but the professor just directed an annoyed glance at you, so you simply choose a convenient seat. The lecture hall is now filled with a concert of metallic clunks and jerks, as everybody flaps down their seats and tables, and the lecture begins.

The first ten minutes go quite well. You are taking notes and following the information being presented. But after about fifteen minutes, you can feel that espresso wearing off. After thirty minutes, you are almost back in the state in which you left the house in the morning, only now you must sit still for another hour and try to pay attention to the lecture. The hum of the projector paired with the ventilation system feel like a white noise lullaby, calling you to shut down again. By the time you have reached the second half of the lecture, you are busy enough wrestling with yourself to stay awake, that each lecture slide starts to look the same. Finally, you are elated as the lecturer releases you from quasi-hibernation after ninety minutes. As you leave the lecture hall without any solid grasp of what was discussed in class just now, you cannot help but think that it would have been a better idea to have stayed in bed.

While some of the causes of such an experience are certainly to be attributed to sub-optimal practices of the student (e.g. not getting enough sleep), the lecture format itself may also be contributing its fair share of problems. At least that is the view of team Quintessence, which studied the way students perceive attention in university lectures here at TUM and set out to find interventions which would promise its enhancement.

The team, made up of people with extremely diverse study-backgrounds (chemistry, physics, sports science, management & technology and mathematics), initially had little scientific domain knowledge in applied psychology, the field in which their project would arguably fall. But an intensive undertaking in literature research together supported by two expert supervisors (Dr. Susanne Witzgall, Akademie der Bildenden Künste, Head of cx Centre for Interdisciplinary Studies, and Prof. Dr. Hans Förstl, Chair for Clinical Psychiatry und Psychotherapy at TUM) and a dedicated tutor (Sebastian Kaltenbach) allowed them to gain an insight into the relevant topics.

Theories and research on attention, especially in the setting of education, are extensive. And while statements like *"You Now Have a Shorter Attention Span Than a Goldfish"* (as once showcased on the cover of Time Magazine) make for a good headline, these kinds of comparisons lack scientific rigor. However, according to the preliminary research of team Quintessence, there exists consensus on certain issues. For example, there seems to be a limit as to how long humans can continuously pay attention to an activity which demands it, as is the case for university lectures. In fact, since the latter half of the twentieth century, it has been well established that effects of attention-loss can already be observed after ten to fifteen minutes for tasks requiring a constant level of significant mental activity. Hence, you should not be surprised if you feel a dip, low or crash after the first quarter hour of a lecture, regardless of having had an espresso before or not. Given that lectures at TUM tend to be administered in ninety-minute blocks, this is seemingly in dissonance with the results from various psychological papers.

In light of this, the team hypothesized that a lecture break could have a significant impact on the perceived attention of the attending students. First validation occurred in the form of two case-studies performed at ETH Zurich and RWTH Aachen. At ETH, the timetable follows a strict regimen of consecutive hour-blocks, consisting of a forty-five minutes class and fifteen minutes break each. Instead, at RWTH a service had been set up by their university sports center, which a lecturer could hire, to perform a five-minute activity break in the middle of class. Both concepts sounded intriguing and had merit, which prompted Quintessence to conduct their own study here at TUM and test their hypotheses. Over the course of seven weeks in November and December 2019, the team tested two different break formats (one passive, one with guided activity) of varied length (five and ten minutes) and across a wide range of faculties and lecture sizes.

The results? Indeed, the team was able to measure positive tendencies in response to the applied measures (see scientific report on pages [164 – 171] for detailed presentation and discussion of methods/results), and while some students expressed concerns about distraction, a majority seems to respond to the introduced measures in a positive way. "I thought the activity break was great. It helped my concentration and made the lecture more relaxed," one participant wrote as anonymous feedback. At the same time, the lecturers who participated have also been generally encouraging about the studies' administration. However, the data has also shown inconsistencies regarding the level to which the measures are effective, offering strong evidence that their effectivity must also be highly dependent on other aspects (e.g. subject taught, the lecturers and their teaching styles, etc.). Thus far, the tested interventions do not significantly factor out these parameters and can therefore not be considered to guarantee improvement of students' perceived attention in a universal lecture setting.

It remains to be seen if the work of team Quintessence will yield the implementation of breaks at TUM as being *quintessential*. In any case, it will most certainly raise awareness about the current lecture practices at TUM. Perhaps the time has come for a shift in teaching culture. ■

Quintessence

Table of contents:

Abstract

1. Background

2. Goals andmethods
   1.2 Goals
   2.2 Methods

3. Outcome and Discussion

4. Summary and future goals

References

Abstract

Attention represents a complex function that is relevant to a multitude of human activities. However, while a lot of research on attention has already been conducted, relatively few studies have focused on university students.

Thus, the primary objective of this study was to investigate the effects of distinct break concepts and durations on the individually perceived attentiveness of university students in lecture contexts. Thereby, a comprehensive approach involving the capture of students' subjective perceptions via a questionnaire and the measurement of several environmental parameters was taken.

We found that breaks, which may or may not involve physical activity, appeared to improve students' individually perceived attentiveness significantly, while longer breaks did not show stronger effects than shorter ones. On the other hand, the magnitude of these effects showed to be context-specific and influenced by diverging environmental conditions. Consequently, despite the necessity of additional research, this analysis contributes to an enhanced understanding of attentiveness in a university context.

1. Background

While there are various diverging definitions of the concept of attention [1, 2, 3], the overall scientific consensus appears to suggest that the capacity of prolonged attention (as quantifiable by the measure of "attention spans") is an essential requirement for academic performance. This has been underlined by studies on the implications of attention deficit hyperactivity disorder for school children and adolescents [4, 5, 6]. Consequently, the arising question of how to optimize the potential for attention is intensely debated in educational discussions [7,8].

In this context, a set of studies have provided valuable insight into the factors that influence attention. These include intrinsic ones which solely depend on the individual's inherent physical and psychological characteristics, such as age, intelligence, mental illnesses, circadian rhythms or moods [9, 10, 11, 12, 13]. Extrinsic factors include environmental conditions e.g. noise, light, and also the influence of psychostimulants like coffee and tea [14, 15]. Therefore, it seems plausible that attention spans can be maximized by optimizing the parameters associated with intrinsic and extrinsic factors.

More specifically, the introduction of breaks has been proposed and successfully applied in the past to augment attentiveness of humans in various contexts [16, 17, 18, 19, 20]. However, one important caveat of the above-cited studies is that they usually focus on children, adults or elderly subjects. In contrast, research with regard to the optimization of attentiveness in a university context turns out to be scarce. Moreover, different opinions exist among scientists regarding the optimal length of breaks and whether they should involve physical exercises [21, 22, 23, 24, 25,26].

In light of these issues, we investigated strategies for the improvement of individually perceived attentiveness of university students by assessing different implementation concepts of breaks in lectures. Our comprehensive approach included the testing of various break lengths and activities. It was aimed at resolving some of the remaining controversies concerning the optimal nature of attention-enhancing breaks in university lectures.

2. Goals andmethods

1.2 Goals

The primary aim of our project was to improve the individually perceived attentiveness of TUM-students in university lectures by 2020. To that end, we investigated the extent to which breaks can constitute implementable measures that augment said attention in university lectures.

In particular, three distinct break concepts ("Treatments") were considered (see Fig. 1). Treatment I was a "conventional" 90-minute lecture without any break, serving as a control. Whereas, Treatment II featured a break without physical activity of either five or ten minutes, while Treatment III involved a five- or ten-minute break with physical activity.

Possible effects on the students' individually perceived attentiveness were assessed via a questionnaire-based interrogation. In light of the above-discussed complexity of attention, one central issue in the context of this study was the design of a sum score – i.e. a single scalar that measured the individually perceived attentiveness – to allow a straightforward comparison amongst the

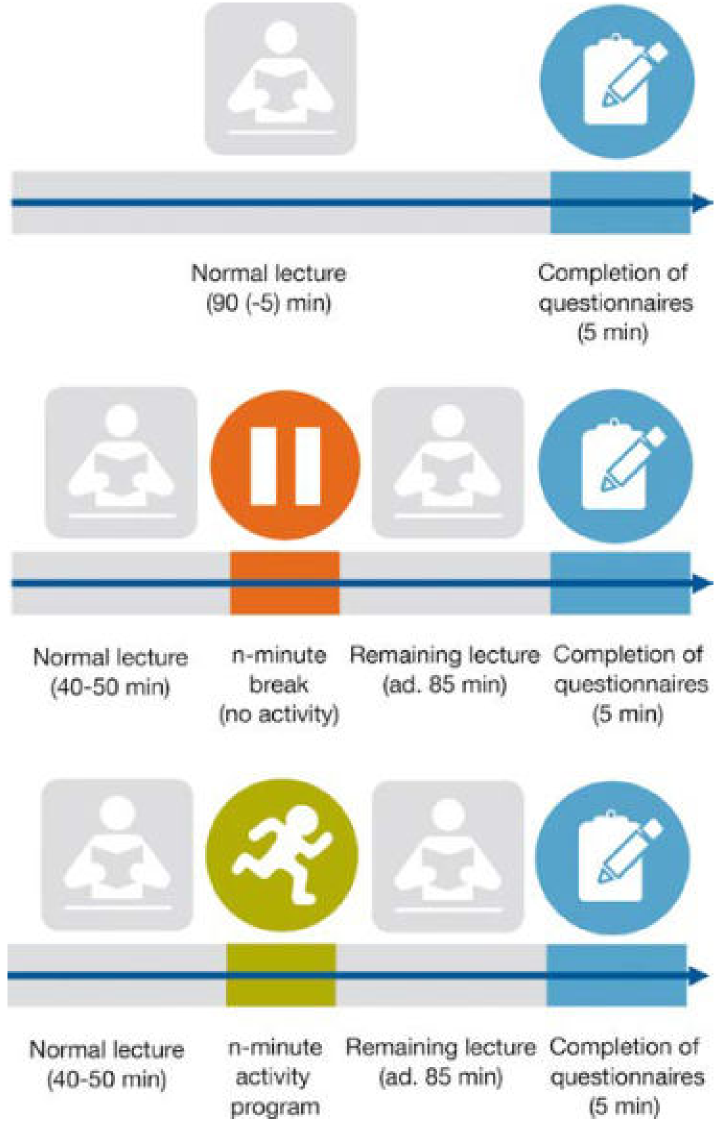


Fig. 1: Scheme describing the three different break concepts ("Treatments"; I-III) analyzed in this study. In each case, students were asked to fill out the respective questionnaire at the very end of the lecture.

three Treatments. Evidently, such a sum score must comprise a many facets of attention in the context of university lectures, e.g. the prevailing environmental conditions, general physical and mental features as well as momentary emotions of the students, and the modality of the presentation of the contents by the lecturer. Thus, the sum score was realized by conceptualizing a questionnaire that included all of the discussed aspects.

The outcomes of this study may have implications for the lecture practices at TUM by serving as a scientific basis for the design of guidelines to optimize the lectures' structure. This appears to be of particular relevance with regard to TUM's Future Learning Initiative which focuses on the development of new concepts to promote dynamic and future- oriented teaching at TUM [27]. More globally, the research presented here contributes to a better understanding of attention – especially in a university context.

2.2 Methods

A total of six different 90-minute courses taught on a weekly basis at different scientific faculties were analyzed (see Tab. 1). Each lecture was subjected to the Treatments I, II, and III (in the given order; see Fig. 1) throughout three consecutive weeks. In the case of course 1, the treated lectures were separated by a time interval of two weeks as an exception. The program of Treatment III was invariably led by the professional instructor Christof Wendt using a defined set of stretching and activity exercises of either 5 or 10 minutes length.

To assess the individually perceived attentiveness of students during the observed university lectures, three questionnaires in German language (one per Treatment) were administered. These allowed for surveying the attending students whilst taking into account their age, gender, and semester. The questionnaires comprised items that were each composed of a statement and an associated six-point rating scale reflecting the students' level of agreement. Each questionnaire consisted of the same 14 items which equally contributed to the above-mentioned sum score. Treatment II and III included additional items that were not considered for calculating the sum score. These were incorporated to survey Treatment-specific impressions of the students. For more detailed information concerning the used questionnaires, the reader may refer to[28].

#	Course title	Lecturer	Date and start time	# of seats of the lecture hall	Ø # of completed questionnaires	Break length (treatment II and III)
1	Biotechnologie für Ingenieure	Prof. S. Berensmeier	Tuesday, 2:30 pm	I: 80 II and III: 88	32	5
2	Einführung in die Methoden der empirischen Sozialforschung	C. Petz (II: Prof. J. Pfeffer)	Wednesday, 1:15 pm	188	60	5
3	Bodenordnung und Landentwicklung	Prof. W. de Vries	Friday, 8:00 am	60	12	5
4	Einführung in die Pädagogik	Prof. F. Mess	Tuesday, 9:45 am	843	228	10
5	Lineare Algebra für Elektrotechnik	Prof. S. Weltge	Thursday, 3:00 pm	843	234	10
6	Ernährung, Bewegung und Gesundheit	Dr. T. Schulz	Friday, 10:15 am	304	80	10

Tab. 1: Overview of the examined university courses including information on the course, the lecturer, the lecture hall, and the number of students attending the lecture. Treatment-specific details denoted by the corresponding identifier of the Treatment (cf. Fig. 1).

Additionally, the environmental conditions prevailing in the lecture hall, i.e. noise, temperature, air humidity, and the concentration of CO_2, were consistently probed using an IC-Meter device.

The data analysis was carried out using the statistical programming language R. The source code is accessible at [28]. Approaches of descriptive statistical methods, e.g. box plots and histograms, were used for socio demographic data as well as results of the survey. To allow further deductions, inferential methods, e.g. linear regression modelling and modelling with interaction effects, were used.

3. Outcome and Discussion

Within the scope of this study, a total of 512 triplets (belonging to Treatments I, II,and III) of questionnaires were gathered in six different university courses and analyzed with respect to the respective sum score. The collected raw data is shown in Fig. 2 as box-and-whisker-plots. Note, that no statements of statistical significance can be directly derived from the mere visualization of the data. Never the less, a qualitative analysis of those plots serves as an intuitive entry point for the interpretation of the obtained data.

In this context, it is apparent that the interquartile ranges are of comparable order of magnitude (between 8.5 and 14.8) for all courses and Treatments. Given the assumption that the interquartile ranges represent adequate proxies for the variances of the sum score distributions, one can conclude that the latter are also in a similar range. Similarities of variances may indicate that the distributions obtained from courses with small sample sizes (e.g. course 1 and course 3) are still representative. In other words, biases due to small sample sizes can be assumed as negligible. This view is supported by the moderate number of outliers in the box- and-whisker-plots (see Fig.2).

Moreover, we observed a global trend that the sum score median becomes more elevated in case of Treatments II and III as com-

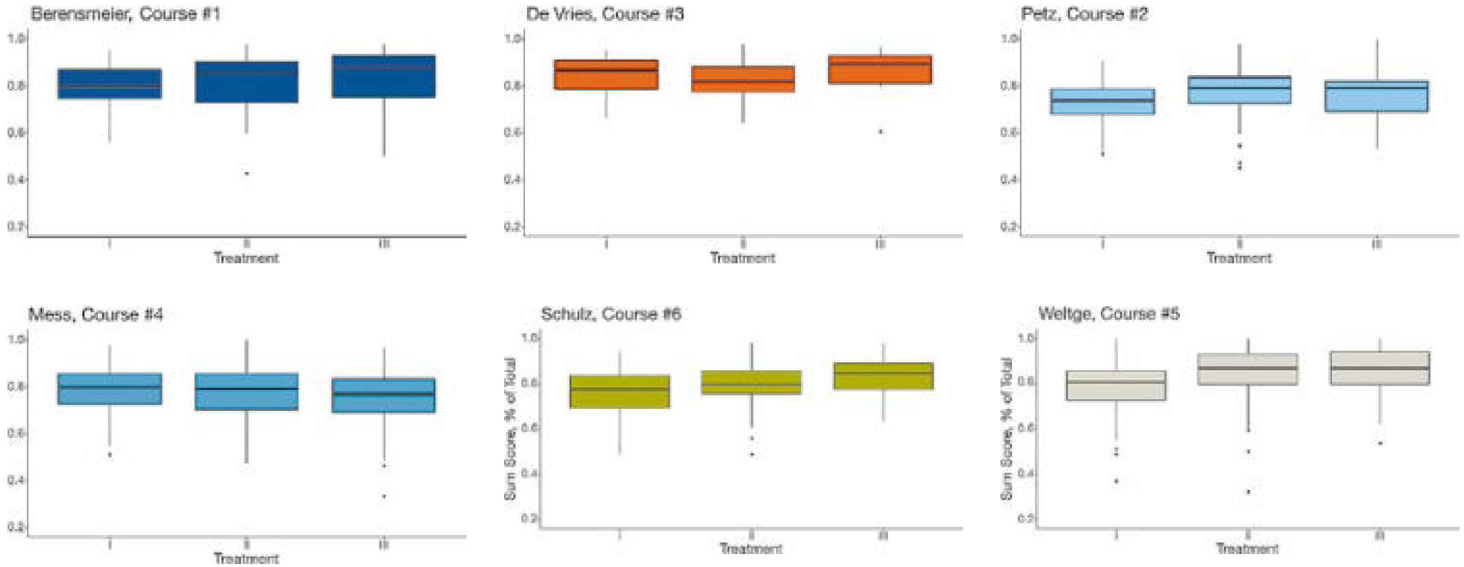


Fig. 2: Box-and-whisker-plots summarising the results of the questionnaire-based survey of different university courses (cf. tab. 1). In each case, the sum score (normalised with respect to the maximal, theoretically achievable sum score) is plotted against the effected Treatment. The median is denoted by a bold black line and the upper resp.lower boundary of the surrounding box signifies the upper resp. lower quartile. The associated whiskers visualise the minimal and maximal values. Circles represent outliers with a distance of at least 1.5 times the interquartile range to the boxes' boundaries. NB: While these plots reflect the obtained raw data and may adumbrate rough tendencies, no significant statements can be deduced from them without further data analysis (see maintext).

pared to Treatment I. This may hint at the efficacy of a passive (Treatment II) or active (Treatment III) break in lectures with regard to improving the individually perceived attentiveness among university students. However, the fact that courses 3 and 4 do not follow this trend stresses the importance of a more rigorous, statistically sound analysis of the data.

Consequently, a linear regression analysis paired with hypothesis tests, particularly t-tests, was carried out to investigate the relationship between the sum score and the Treatments. In principle, this allows to draw conclusions concerning the statistical significance of certain trends. The null-hypothesis assumed that neither the existence, nor the type of break have an effect on the sum score. For sake of simplicity, we additionally assumed that the different courses were sufficiently similar with respect to the parameters of the lectures, such as the lecturer's delivery or environmental conditions. This simplified view enabled treating the different courses and their students as one homogeneous population that forms the basis of our linear regression analysis. While detailed data emerging from this statistical evaluation procedure may be retrieved from [28], core results suggests that the incorporation of a break into a lecture (Treatment II resp. III) is associated with sum scores that are significantly higher as compared to those of break-free lectures (Treatment I; significance level: 1 %; average improvement of the sum score of ca. 2 to 2.5 points, which equals 2.4 to 3.0 percentage points in relative terms). In contrast, Treatment III shows non-significantly higher sum scores than Treatment II. While there is a tendency that breaks with durations of 10 minutes (course 4 to 6)are associated with higher sum scores compared to those of 5 minutes length (course 1 to 3), these differences turn out to benon-significant.

Hence, the combined data suggests that the implementation of a break in the context of a university lecture significantly improves students' individually perceived attentiveness as quantified by the introduced sum score. However, differences between breaks, with respect to activity and duration, appear to be moderate.

Next, it was tested whether the initial assumption of a homogeneous population of courses and students is justifiable. To this end, the collected data was statistically examined with regard to the potential presence of interaction effects, i.e. the presence of other causal variables that have an effect on the discussed relations between Treatment and sum score. This showed that such effects are indeed detectable. For instance, the relation between Treatment and sum score is influenced by the nature of the course. This is reflected in courses 2 and 4 having significantly lower sum scores than others in case of Treatments 1 and 3. The presence of this observed interaction severely challenges the postulate of a homogeneous set of courses and students.

A partial explanation for the previously discussed interaction can be derived from the measurements of prevailing environmental circumstances that were carried out over the course of the studied lectures. While some parameters, such as temperature and humidity, appear almost constant throughout the Treatments, average CO$_2$ concentrations and noise levels exhibit quite drastic differences (see Fig. 3). As the latter two have been shown to affect the attentiveness of humans in earlier studies [29,30], it is reasonable to suggest that fluctuations of these parameters may influence the sum score. For instance, course 2 shows the overall highest CO$_2$ values at Treatment I (see Fig. 3 A), which correlates with a relatively low sum score. Some of the measured CO$_2$ concentration values lie above 690 ppm which has been found to be the threshold above which attentional capacities of students in primary school classes decrease [31]. This implies that there may be room for improvement with regard to the ventilation conditions present in the respective lecture halls at TUM.

Another conclusion that can be drawn from the measured data is that there is no global trend of elevated CO2 concentration or noise levels in case of Treatment III (see Fig. 3). While one might intuitively presume that physical activity is associated with an unfavorable increase in these parameters, this does not become apparent from our measurements.

In addition to other interesting insights, fluctuating environmental parameters may thus provide a plausible explanation for external influences on the relation between Treatment and sum score. However, the origin of these interaction effects cannot be exclusively attributed to fluctuating environmental parameters, but may well arise from other sources, e.g. the lecturer's delivery, the lecture's content or the time at which the lecture is held. This is underlined by the fact that the sum score performance does not always correlate with the values of the environmental parameters. Exemplarily, course 4 exhibits relatively poor sum scores at Treatment III in spite of a low prevailing CO$_2$ concentration (see Fig. 3 A). Therefore, further research may contribute to identifying more of the underlying factors.

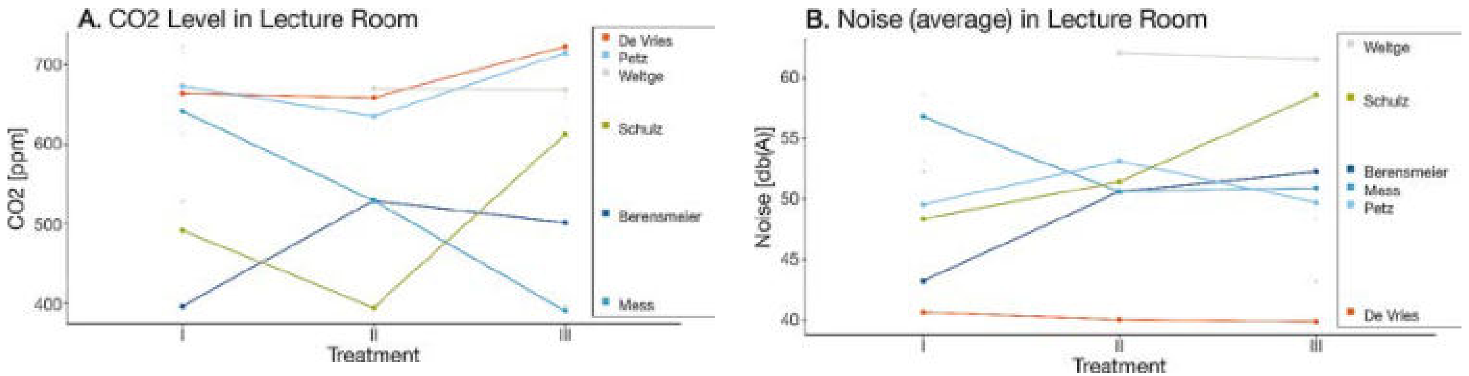


Fig. 3: Line charts visualising selected environmental conditions prevailing in the lecture halls of different university courses (cf. tab. 1) as a function of the respective Treatment. In case of Treatment I of lecture 5, no data is available due to technical issues during the measurement. A) Carbon dioxide concentration (denoted in parts per million). B) Average noise (denoted in A-weighted decibels).

4. Summary and future goals

In summary, the presented work provides evidence that the introduction of breaks in a lecture context represents an effective tool to enhance the individually perceived attentiveness of university students. It contributes to scientifically underlining the potential benefits of various initiatives promoting the incorporation of breaks into university schedules, such as the "Pausenexpress" project of the German university sports association (ADH) [32].

However, there is one important caveat to the conclusions of this study: As previously mentioned, the assumption of a homogeneous course- and student-base represents a simplification which was underlined by the analysis of interaction effects. In principle, one could explicitly account for these variables by applying more complex models. Expanding the investigated sample size might also help to deduce statistically significant conclusions in spite of an expanded parameter space.

Nevertheless, the obtained results are still valid under the given assumptions and, as such, may serve as a starting point for the creation of guidelines to implement break concepts at TUM. More globally, said guidelines might help to create a more prosperous and stimulating educational environment and thereby contribute to TUM's ongoing aspiration for better knowledge transfer, as reflected in the TUM: Future Learning Initiative. ■

References

1. https://www.britannica.com/science/attention. Retrieved March 30,2020.
2. Anderson, J. R. (2005). Cognitive Psychology and Its Implications. (p. 519) Macmillan.
3. Gardner, D. G., Dunham, R. B., Cummings, L. L., & Pierce, J. L. (1989). Focus of attention at work: Construct definition and empirical validation. Journal of Occupational Psychology, 62 (1), 61–77. https://doi.org/10.1111/j.2044-8325.1989.tb00478.x
4. Biederman, J., Nwecorn, J., & Sprich, S. (1991). Comorbidity of attention deficit hyperactivity disorder with conduct, depressive, anxiety, and other disorders. American Journal of Psychiatry, 148(5), 564–577. https://doi.org/10.1176/ajp.148.5.564
5. Birchwood, J., & Daley, D. (2012). Brief report: The impact of Attention Deficit Hyperactivity Disorder (ADHD) symptoms on academic performance in an adolescent community sample. Journal of Adolescence, 35 (1), 225–231. https://doi.org/10.1016/j.adolescence.2010.08.011
6. Daley, D., & Birchwood, J. (2010). ADHD and academic performance: why does ADHD impact on academic performance and what can be done to support ADHD children in the classroom? Child: Care, Health and Development, 36 (4), 455–464. https://doi.org/10.1111/j.1365-2214.2009.01046.x
7. https://www.academia.edu/25039190/Managing_Attention_Span_in_the_Digital_Age. Retrieved April 10,2020
8. https://www.telegraph.co.uk/news/2018/05/17/chinese-school-uses-facial-recognition-monitor-student-attention/. Retrieved March 30,2020.
9. Commodari, E., & Guarnera, M. (2008). Attention and aging. Aging Clinical and Experimental Research, 20 (6), 578–584. https://doi.org/10.1007/bf03324887
10. Stankov, L. (1983). Attention and intelligence. Journal of Educational Psychology, 75 (4), 471–490. https://doi.org/10.1037/0022-0663.75.4.471
11. Hanley, M., Khairat, M., Taylor, K., Wilson, R., Cole-Fletcher, R., & Riby, D. M. (2017). Classroom displays – Attraction or distraction? Evidence of impact on attention and learning from children with and withoutautism. Developmental Psychology, 53 (7), 1265–1275. https://doi.org/10.1037/dev0000271
12. Valdez, P., Ramírez, C., García, A., Talamantes, J., Armijo, P., & Borrani, J. (2005). Circadian rhythms in components of attention. Biological Rhythm Research, 36 (1–2), 57–65. https://doi.org/10.1080/09291010400028633
13. Rokke, P. D. ., Arnell, K. M., Koch, M. D., & Andrews, J. T. (2002). Dual-task attention deficits indysphoric mood. Journal of Abnormal Psychology, 111 (2), 370–379. https://doi.org/10.1037/0021-843x.111.2.370
14. Castro-Martínez, J. A., Chavarría Roa, J., Parra Benítez, A., & González, S. (2017). Effects of classroom- acoustic change on the attention level of university students. Interdisciplinaria: Revista de Psicología Y Ciencias Afines, 33 (2). https://doi.org/10.16888/interd.2016.33.2.1
15. McLellan, T. M., Caldwell, J. A., & Lieberman, H. R. (2016). A review of caffeine's effects on cognitive, physical and occupational performance. Neuroscience & Biobehavioral Reviews, 71, 294–312. https://doi.org/10.1016/j.neubiorev.2016.09.001
16. Brauer, M. (2014). An der Hochschule lehren. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642- 42006-1
17. Howie, E. K., Schatz, J., & Pate, R. R. (2015). Acute Effects of Classroom Exercise Breaks on Executive Function and Math Performance: A Dose–Response Study. Research Quarterly for Exercise and Sport, 86 (3), 217–224. https://doi.org/10.1080/02701367.2015.1039892
18. Bennett, A. (2015). Take five? Examining the impact of microbreak duration, activities, and appraisals on human energy and performance. (Doctoral dissertation). Retrieved from VCU University Archives.
19. Anderson, W. A., & Harrison, B. (1985). Lecture break. Journal of Agronomic Education, 14, 105–108.
20. Dababneh, A. J., Swanson, N., & Shell, R. L. (2001). Impact of added rest breaks on the productivity and well being of workers. Ergonomics, 44 (2), 164–174. https://doi.org/10.1080/00140130121538
21. Howie, E. K., Schatz, J., & Pate, R. R. (2015). Acute Effects of Classroom Exercise Breaks on Executive Function and Math Performance: A Dose–Response Study. Research Quarterly for Exercise and Sport, 86 (3), 217–224. https://doi.org/10.1080/02701367.2015.1039892
22. Bennett, A. (2015). Take five? Examining the impact of micro break duration, activities, and appraisals on human energy and performance. (Doctoral dissertation). Retrieved from VCU University Archives.
23. Hill, L., Williams, J. H. G., Aucott L., Milne, J., Thomson, J., Greig, J., Munro, V., & Mon-Williams, M. (2010). Exercising attention within the classroom. Developmental Medicine & Child Neurology, 52 (10), 929–934. https://doi.org/10.1111/j.1469-8749.2010.03661.x
24. Schmidt, M., Benzing, V., & Kamer, M. (2016). Classroom-Based Physical Activity Breaks and Children's Attention: Cognitive Engagement Works! Frontiers in Psychology, 7. https://doi.org/10.3389/fpsyg.2016.01474
25. Wilson, A. N., Olds, T., Lushington, K., Petkov, J., & Dollman, J. (2016). The impact of 10-minute activity breaks outside the classroom on male students' on-task behaviour and sustained attention: a randomised crossover design. Acta Paediatrica, 105 (4), e181–e188. https://doi.org/10.1111/apa.13323
26. Osnabrücker Forschungsgruppe (2016). Mittagsfreizeit an Ganztagsschulen. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-11623-1
27. https://www.tum.de/studium/im-studium/future-learning/. Retrieved March 29, 2020.
28. Papazoglou-Hennig, J., Hutschenreiter, S., Huber, D., Hasbach, S., Gandorfer, S., & Frey, D. M. (2020,May 14). Investigation of the effects of different break concepts on the attention of students during university lectures: Supplementary Information (Version 1.0.0). Version 1.0.0. https://doi.org/10.5281/ZENODO.3827961
29. https://www.aerzteblatt.de/nachrichten/102938/Zahl-der-Menschen-mit-drittem-Geschlecht-geringer-als-angenommen. Retrieved April 10,2020.
30. Lazovic, I., M., Stevanovic, Z., M., Jovasevic-Stojanovic, M., V., Zivkovic, M., M., & Banjac, M., J. (2016). Impact of CO2 concentration on indoor air quality and correlation with relative humidity and indoor air temperature in school buildings in Serbia. Thermal Science, 20 (suppl. 1), 297–307. https://doi.org/10.2298/tsci150831173l
31. Fernandes, R. A., Vidor, D. C. G. M., & Oliveira, A. A. de. (2019). The effect of noise on attention and performance in reading and writing tasks. CoDAS, 31 (4). https://doi.org/10.1590/2317-1782/20182017241
32. Coley, D. A., Greeves, R., & Saxby, B. K. (2007). The Effect of Low Ventilation Rates on the Cognitive Function of a Primary School Class. International Journal of Ventilation, 6 (2), 107–112. https://doi.org/10.1080/14733315.2007.11683770
33. https://www.adh.de/projekte/pausenexpress.html. Retrieved April 102020.

Self Reflection

Looking back on 20 months of active membership in TUM: Junge Akademie, it has been a remarkable experience for every one of us here at team *Quintessence*. Seeing a scientific project unfold, from conception of ideas to preliminary research, fixing our goals and research question, case studies, planning and conducting our own study up to finally reaping the results, has been an incredible journey filled with lots of challenging and interesting turns along the way.

Our team initially formed under the theme "Perception" in November 2018. The formation process was successful, because, even as we were just starting to engage in open brainstorming, there was a clear feeling of confluence regarding our potential project ideas. We were all interested in the concepts of perception, attention, distraction, and concentration from the standpoint of education practices and corresponding effects on society in general. This gave our whole team significant initial motivation and encouragement, which carried over into the first months of our project work, allowing us to quickly isolate more concrete ideas worth pursuing. These included the development of a fact-checking service to contain the spread of misinformation, as well as the idea of creating a framework for improving the teaching setting at university.

Although our team size of six people appeared manageable, the designation of clear roles was extremely helpful for our organization. Especially, clarifying who is the primary responsible for matters of IT (e.g. set up of calendar, cloud storage, file structure), communication with internal or external actors (e.g. website, external partners, TUMJA-headquarters), general planning (e.g. meetings, timeline, work distribution) gave us some basic structure from which we could work off, while still maintaining the necessary flexibility to assign tasks throughout our team in order to deal with surprises, uncertainty, as well as intermittent absence of team members. Frequent and fixed meetings were also extremely beneficial during the first months, where we sat down together at an almost weekly basis to discuss our progress with preliminary research into scientific literature. From the beginning, we also learned the benefits of divide-and-conquer strategies. By often splitting off into smaller focus groups, we would be able to further analyze potential options regarding our procedure, before making important and significant decisions impacting our project.

Hence, by the end of January 2019, we had already reached a point, where we could clearly formulate a primary goal (*improving the individually perceived attentiveness of TUM-students in university lectures by 2020*) and corresponding research question (*How could an implementable concept be constructed such as to improve the individually perceived attention of TUM students in university lectures?*), along with preliminary hypotheses which we were planning to investigate in that regard. At this point we had also consulted our supervisors, who gave very helpful feedback with respect to a first validation of our hypotheses and the next possible steps.

Our organizational framework enabled us to plan two case studies in May and June 2019: one to ETH Zurich and one to RWTH Aachen. There, we wanted to observe and evaluate possible solution strategies to the end of improving attention in lectures. The planning procedure could have been handled a little more efficiently than it occurred, which resulted in slightly higher travel and accommodation cost. Nonetheless, the insights gained from both trips were valuable in mapping out promising implementation concepts for our own project.

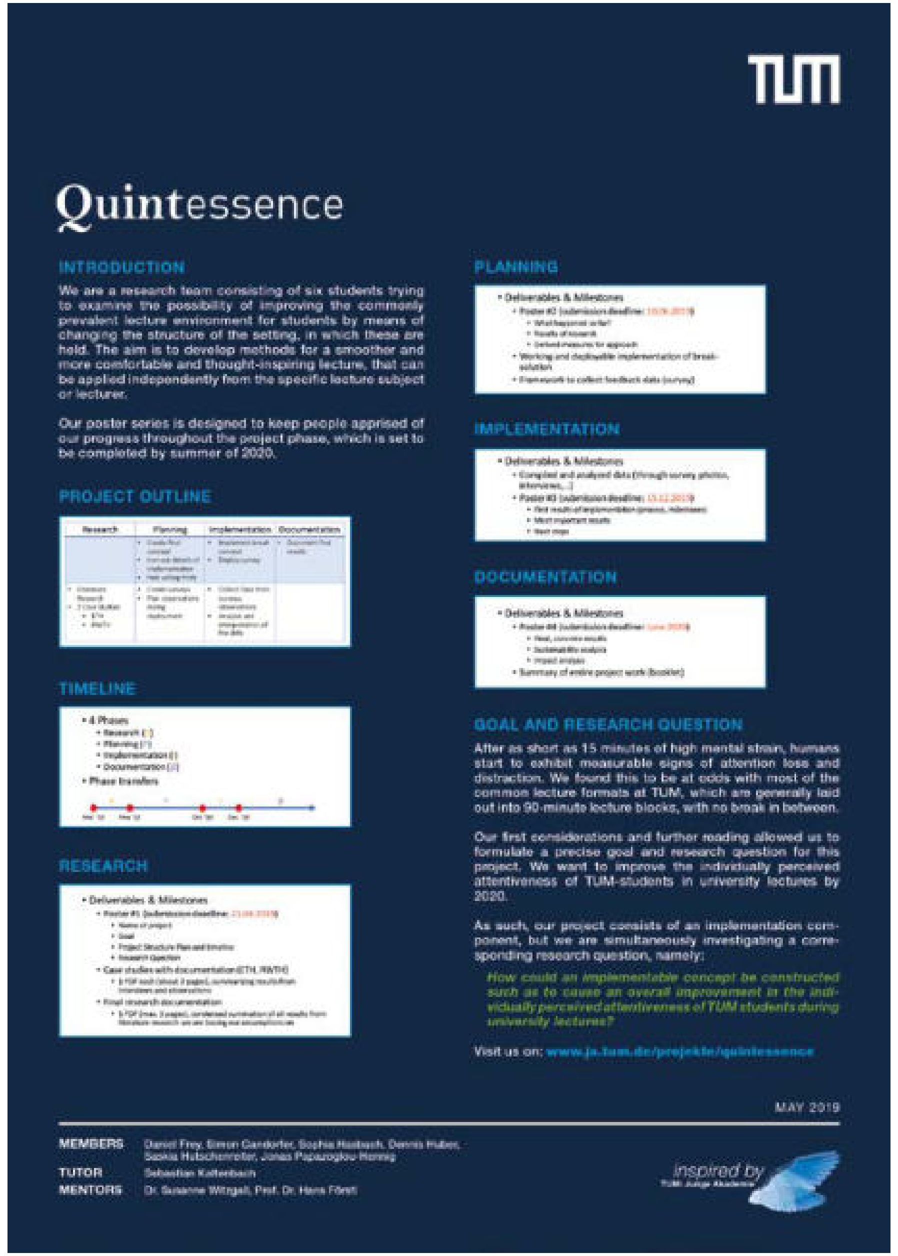
With the knowledge taken away from the case studies and further input from our supervisors, as we approached July 2019, we managed to devise a clear concept for the study of lecture-breaks we wanted to conduct. Our plan was ambitious: Not only did we have to successfully organize a partnership with 6 different lecturers to schedule the administration of our study. We also wanted to design our own questionnaire, to assess the effect of the measures we were testing. For the latter, we cannot stress how valuable the input of our supervisors was in deciding the format and content of our survey. Finding the lecturers was not easy, but greatly aided through the connections made possible by TUM: Junge Akademie. The same was true with regard to preparing the administration of the questionnaires through the survey-platform EvaSys.

While some last-minute changes in schedule were necessary, but as a result of otherwise meticulous and thorough planning, the overall execution of our study in 7 weeks of November and December 2019 went along very well. However, we were extremely distraught over the fact that we had over-printed hundreds of questionnaires, which remained unused and will now have to be recycled. Admittedly, perhaps an online-based questionnaire would have been better from the perspective of sustainability and environmental concerns, yet we made the decision not to proceed in this way in fear of lower response rates. On the other hand, our study resulted in the test of two different lecture break formats (passive and activity- based) across different lengths (5 and 10 minutes) and yielded over 1000 valid questionnaires, giving rise to more than 10000 relevant data points for the analysis of our specifically devised statistical hypotheses. To our knowledge, it is the first time a study of such scale is being executed within the framework of TUM: Junge Akademie, which goes to show how much is possible in this scholarship program.

Overall, we are very satisfied with the development of our project over these past 20 months. We started out with a very vague set of ideas, which we managed to transform and incorporate into much of the work we completed since then. Certainly, it was an advantage that we were able to organize ourselves very efficiently right from the start, but we were also lucky that none of our plans went incredibly wrong, which allowed for a mostly smooth evolution of the project.

Acknowledgements
Our project would not have turned out the way it did without the valued support of our tutor Sebastian Kaltenbach, whose experience in TUM: Junge Akademie was invaluable to our process and whose commitment, attending most of our meetings and workshops, was highly appreciated. Further, we would like to thank our supervisors, Dr. Susanne Witzgall and Prof. Dr. Hans Förstl, for their distinguished perspective and input from their fields, which they both brought to the table. We are also very grateful for the lecturers, who entrusted us with their time to give us the possibility of performing our study in their lectures. We therefore extend many thanks to Prof. Dr. Sonja Berensmeier, Prof. Dr. Walter deVries, Prof. Dr. Filip Mess, Ms. Cindarella Petz, Prof. Dr. Jürgen Pfeffer, Dr. Thorsten Schulz, and Prof. Dr. Stefan Weltge. We are also very grateful for the collaboration with Christof Wendt, who devised and presented the program for all activity breaks. Finally, this entire enterprise would not have been possible without the resources provided by TUM: Junge Akademie, in particular due to the efforts of Maria Hannecker, Peter Finger as well as the entire team, who kept things running in the background as we were allowed to work on our project.

Thank you for this opportunity. ■



Quintessence

INTRODUCTION

We are a research team consisting of six students trying to examine the possibility of improving the commonly prevalent lecture environment for students by means of changing the structure of the setting, in which these are held. The aim is to develop methods for a smoother and more comfortable and thought-inspiring lecture, that can be applied independently from the specific lecture subject or lecturer.

Our poster series is designed to keep people apprised of our progress throughout the project phase, which is set to be completed by summer of 2020.

PROJECT OUTLINE

TIMELINE

- 4 Phases
  - Research
  - Planning
  - Implementation
  - Documentation
- Phase transfers

RESEARCH

- Deliverables & Milestones
  - Poster #1 (submission deadline: [illegible])
    - Name of project
    - Goal
    - Project Structure Plan and timeline
    - Research Question
  - Case studies with documentation (ETH, RWTH)
  - Final research documentation

PLANNING

- Deliverables & Milestones
  - Poster #2 (submission deadline: [illegible])
  - Working and deployable implementation of break-solution
  - Framework to collect feedback data (survey)

IMPLEMENTATION

- Deliverables & Milestones
  - Compiled and analysed data (through survey, photos, interviews,...)
  - Poster #3 (submission deadline: [illegible])
    - Most important results
    - Next steps

DOCUMENTATION

- Deliverables & Milestones
  - Poster #4 (submission deadline: June 2020)
    - Real, concrete results
    - Sustainability analysis
    - Impact analysis
  - Summary of entire project work (booklet)

GOAL AND RESEARCH QUESTION

After as short as 15 minutes of high mental strain, humans start to exhibit measurable signs of attention loss and distraction. We found this to be at odds with most of the common lecture formats at TUM, which are generally laid out into 90-minute lecture blocks, with no break in between.

Our first considerations and further reading allowed us to formulate a precise goal and research question for this project. We want to improve the individually perceived attentiveness of TUM-students in university lectures by 2020.

As such, our project consists of an implementation component, but we are simultaneously investigating a corresponding research question, namely:

How could an implementable concept be constructed such as to cause an overall improvement in the individually perceived attentiveness of TUM students during university lectures?

Visit us on: www.ja.tum.de/projekte/quintessence

MAY 2019

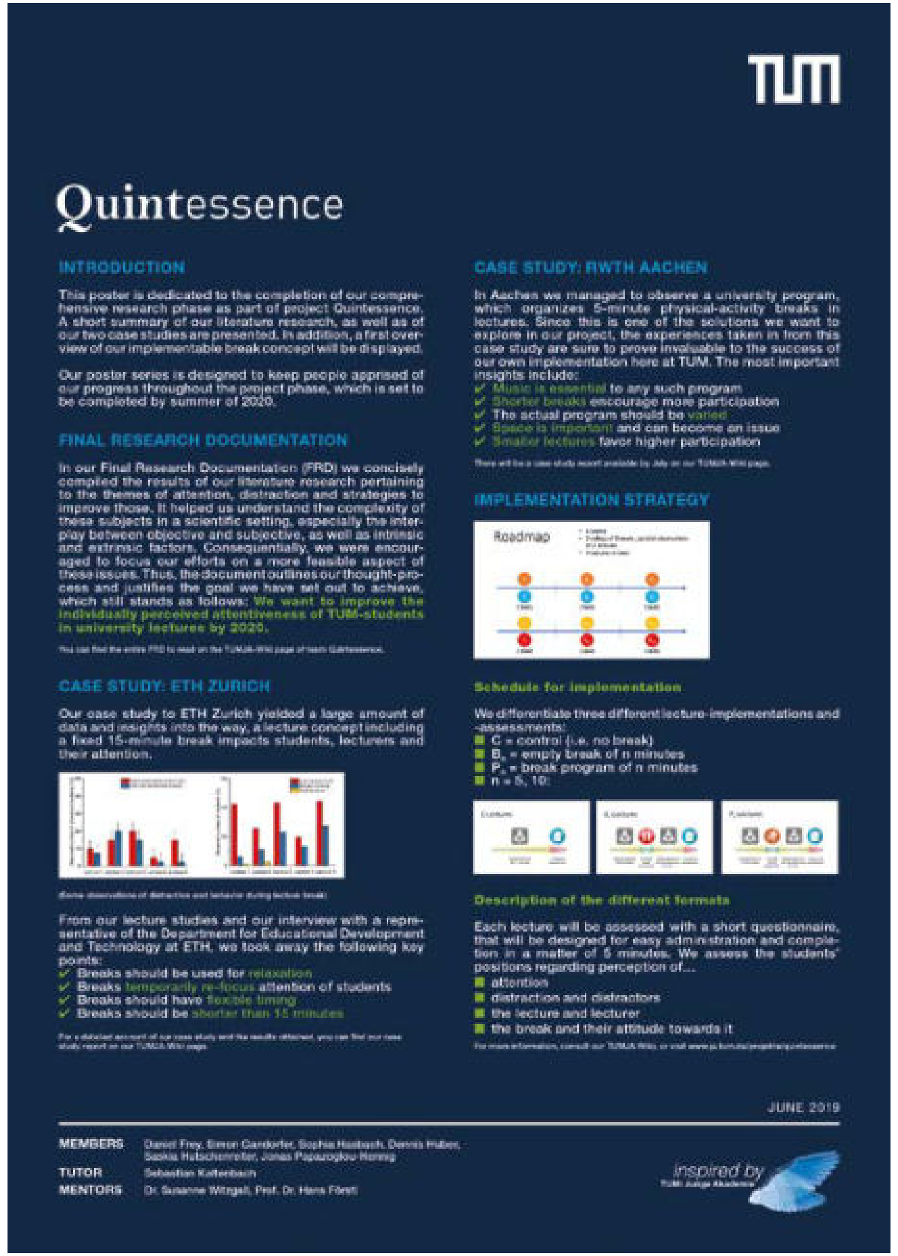
MEMBERS	Daniel Frey, Simon Gandorfer, Sophia Hasbach, Dennis Huber, Saskia Hutschenreiter, Jonas Papazoglou-Hennig
TUTOR	Sebastian Kaltenbach
MENTORS	Dr. Susanne Witzgall, Prof. Dr. Hans Förstl

inspired by TUM: Junge Akademie

POSTER 1: Our team met in November 2019 to discuss the main theme of "Perception" and we soon agreed that, within this field, we were especially interested in questions of human attention span. To find out more about that topic, we first undertook some research. One of the main outcomes of this first research phase was the understanding that, after only about fifteen minutes of intense mental exertion, humans become distracted. After narrowing down the results of our research into different topics, we decided that we wanted to carry out our work within the university environment, partly because this would allow for easy access to sample target groups but, most importantly, because our initial research results strongly contradicted the concept of ninety-minute lecture lengths at most universities. After making this decision, we formulated our project goal: *to improve the individually perceived attentiveness of TUM students in university lectures by 2020.*

During a second research phase, we then figured that a promising and realistic tool for achieving our goal could be lecture breaks and therefore we decided to test different kinds of lecture breaks against each other. We had some ideas about what different kinds of lecture breaks this could entail, but we left this question open at that stage. However, as a result, we also came up with our scientific research question, that is: *How could an implementable concept be constructed such as to cause an overall improvement in the individually perceived attentiveness of TUM students during university lectures?*

To make sure that we could work efficiently, we then divided our project into four different phases and fixed a time span for each of them: a research phase with two case studies, a planning phase, an implementation phase and a documentation phase. The timetable of the four phases as well as our project goal and research question was our first milestone and can be found on our first poster. ■



Quintessence

INTRODUCTION

This poster is dedicated to the completion of our comprehensive research phase as part of project Quintessence. A short summary of our literature research, as well as of our two case studies are presented. In addition, a first overview of our implementable break concept will be displayed.

Our poster series is designed to keep people apprised of our progress throughout the project phase, which is set to be completed by summer of 2020.

FINAL RESEARCH DOCUMENTATION

In our Final Research Documentation (FRD) we concisely compiled the results of our literature research pertaining to the themes of attention, distraction and strategies to improve those. It helped us understand the complexity of these subjects in a scientific setting, especially the interplay between objective and subjective, as well as intrinsic and extrinsic factors. Consequentially, we were encouraged to focus our efforts on a more feasible aspect of these issues. Thus, the document outlines our thought-process and justifies the goal we have set out to achieve, which still stands as follows: **We want to improve the individually perceived attentiveness of TUM-students in university lectures by 2020.**

You can find the entire FRD to read on the TUM:JA-Wiki page of team Quintessence.

CASE STUDY: ETH ZURICH

Our case study to ETH Zurich yielded a large amount of data and insights into the way, a lecture concept including a fixed 15-minute break impacts students, lecturers and their attention.

(Some observations of distraction and behavior during lecture break)

From our lecture studies and our interview with a representative of the Department for Educational Development and Technology at ETH, we took away the following key points:

- ✓ Breaks should be used for relaxation
- ✓ Breaks temporarily re-focus attention of students
- ✓ Breaks should have flexible timing
- ✓ Breaks should be shorter than 15 minutes

For a detailed account of our case study and the results obtained, you can find our case study report on our TUM:JA Wiki page.

CASE STUDY: RWTH AACHEN

In Aachen we managed to observe a university program, which organizes 5-minute physical-activity breaks in lectures. Since this is one of the solutions we want to explore in our project, the experiences taken in from this case study are sure to prove invaluable to the success of our own implementation here at TUM. The most important insights include:

- ✓ Music is essential to any such program
- ✓ Shorter breaks encourage more participation
- ✓ The actual program should be varied
- ✓ Space is important and can become an issue
- ✓ Smaller lectures favor higher participation

There will be a case study report available by July on our TUM:JA-Wiki page.

IMPLEMENTATION STRATEGY

Roadmap

Schedule for implementation

We differentiate three different lecture-implementations and -assessments:

- C = control (i.e. no break)
- B_n = empty break of n minutes
- P_n = break program of n minutes
- n = 5, 10;

Description of the different formats

Each lecture will be assessed with a short questionnaire, that will be designed for easy administration and completion in a matter of 5 minutes. We assess the students' positions regarding perception of…

- attention
- distraction and distractors
- the lecture and lecturer
- the break and their attitude towards it

For more information, consult our TUM:JA Wiki, or visit www.ja.tum.de/projekte/quintessence

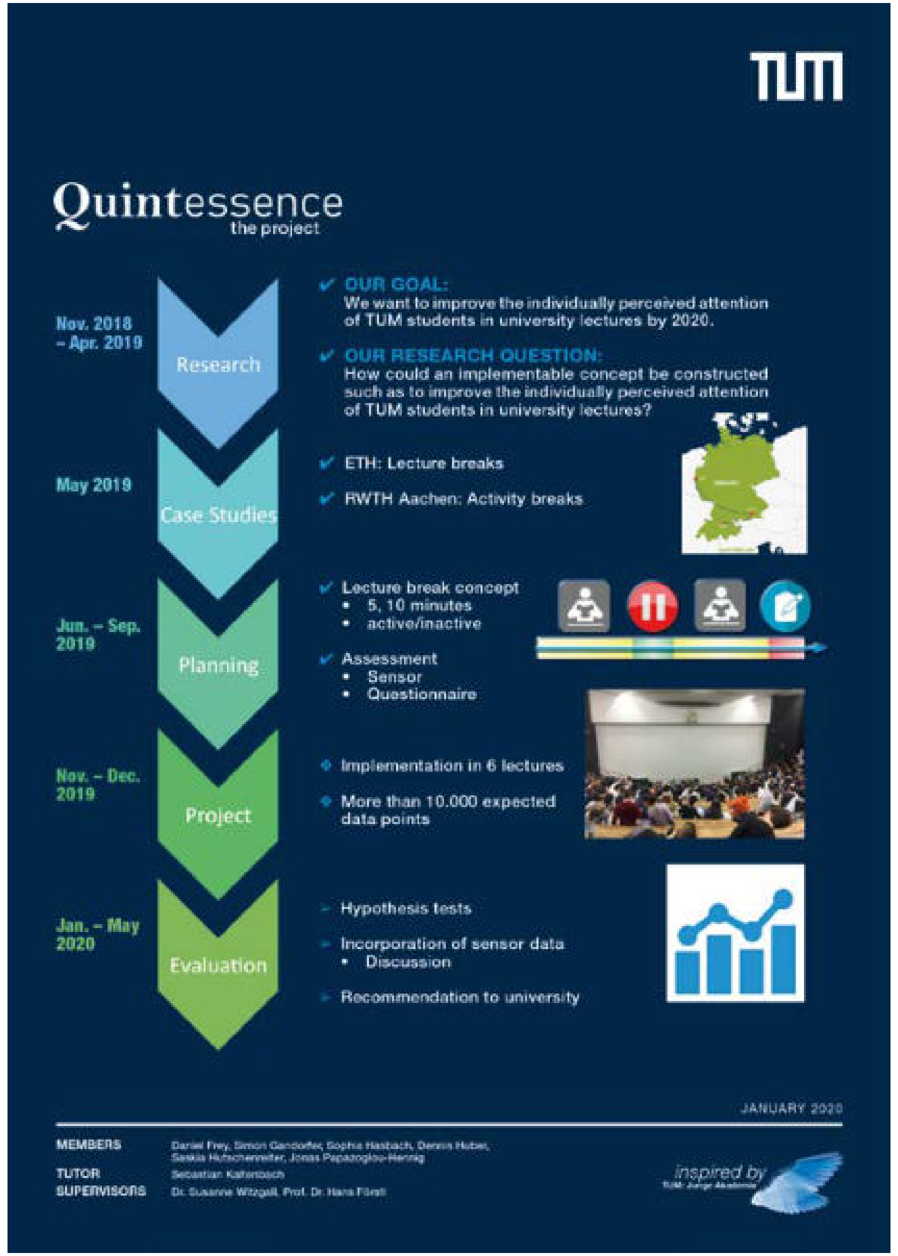
JUNE 2019

MEMBERS	Daniel Frey, Simon Gandorfer, Sophia Hasbach, Dennis Huber, Saskia Hutschenreiter, Jonas Papazoglou-Hennig
TUTOR	Sebastian Kaltenbach
MENTORS	Dr. Susanne Witzgall, Prof. Dr. Hans Förstl

inspired by TUM: Junge Akademie

POSTER 2: Up to the time when the second poster had to be finished, we were still mainly occupied with the research phase. We conducted two case studies, one at ETH Zurich, where there are fifteen-minute breaks after forty-five minutes of each ninety-minute lecture, and the other one at RWTH Aachen, where lecturers can book the "Pausenexpress," a physical lecture break offer by the university sports centre.

The results of these case studies encouraged us in our decision to use lecture breaks as a tool to improve the individually perceived attentiveness of students. Moreover, we were able to finalize what our lecture break concepts should look like specifically. We decided on two different kinds of breaks: a "normal, empty" break and a physical activity break that should both take place after about the first half of the lecture. Both break concepts were supposed to be tested against a normal lecture with no break in it at all (control). As a learning point arising from the two case studies was that the breaks should be shorter than fifteen minutes, we also decided to test both break concepts with a length of five minutes and ten minutes each. By doing this we also made sure that we had a larger variety of break concepts so that we would have a bigger choice as to the one that works best in the end. To measure individually perceived attentiveness, we decided on using a short questionnaire that assesses the students' positions regarding attention, distraction, the lecture and lecturer as well as the break itself. The specific lecture concepts are presented in detail on poster 2. ■



TUM

Quintessence
the project

Nov. 2018 – Apr. 2019 — Research

- ✓ **OUR GOAL:**
  We want to improve the individually perceived attention of TUM students in university lectures by 2020.
- ✓ **OUR RESEARCH QUESTION:**
  How could an implementable concept be constructed such as to improve the individually perceived attention of TUM students in university lectures?

May 2019 — Case Studies

- ✓ ETH: Lecture breaks
- ✓ RWTH Aachen: Activity breaks

Jun. – Sep. 2019 — Planning

- ✓ Lecture break concept
  - 5, 10 minutes
  - active/inactive
- ✓ Assessment
  - Sensor
  - Questionnaire

Nov. – Dec. 2019 — Project

- Implementation in 6 lectures
- More than 10.000 expected data points

Jan. – May 2020 — Evaluation

- Hypothesis tests
- Incorporation of sensor data
  - Discussion
- Recommendation to university

JANUARY 2020

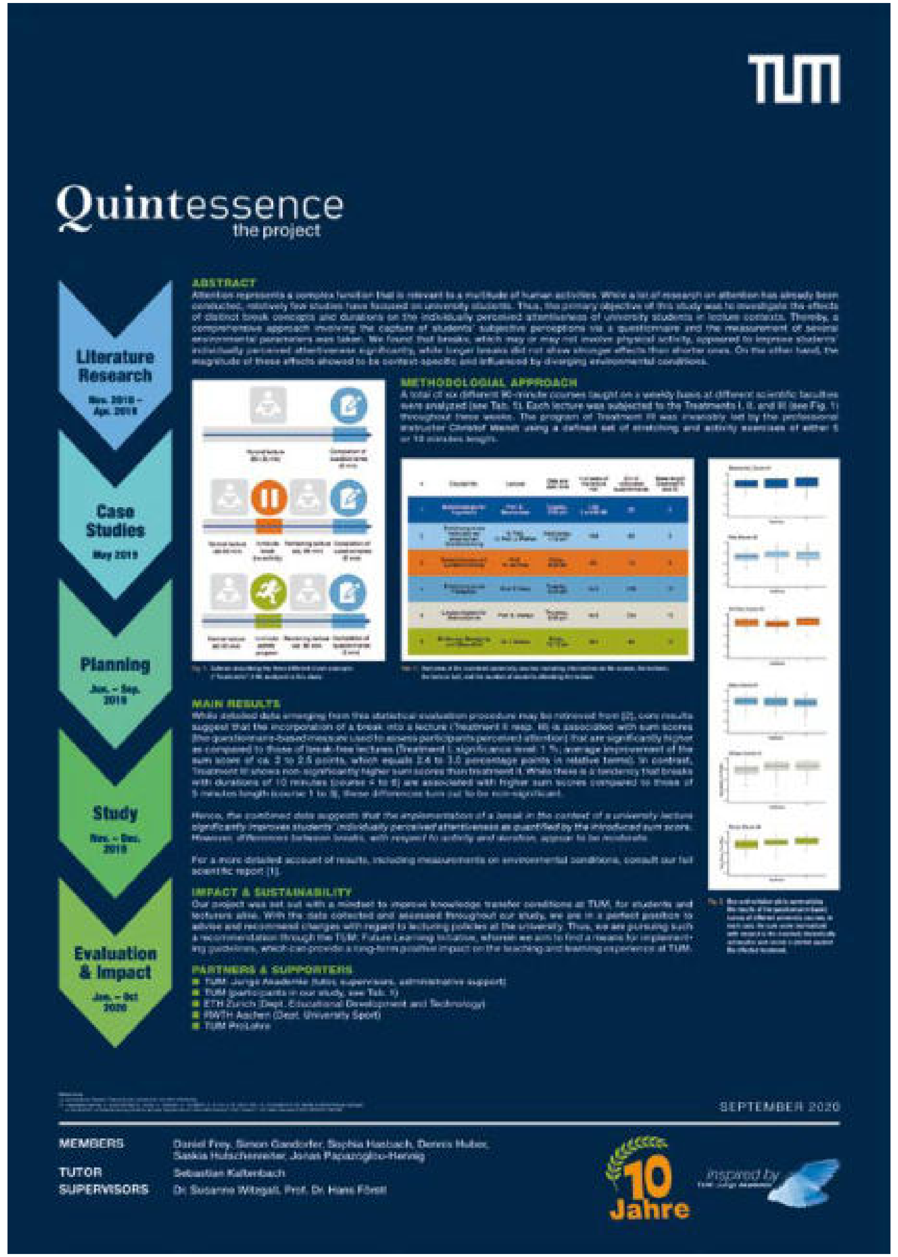
MEMBERS	Daniel Frey, Simon Gandorfer, Sophia Hasbach, Dennis Huber, Saskia Hutschenreiter, Jonas Papazoglou-Hennig
TUTOR	Sebastian Kaltenbach
SUPERVISORS	Dr. Susanne Witzgall, Prof. Dr. Hans Förstl

inspired by TUM: Junge Akademie

POSTER 3: After the research phase was finished, we finally started on planning the concrete implementation. We had already decided on the lecture break concepts, so the main focus here needed to be on how best to make the questionnaire capture relevant data about students' individual attentiveness. Using the results of our research and with the help of our supervisors, we developed twelve items that could be rated from "totally disagree" to "totally agree" and that would provide us with a sum score for each student in each lecture concept. These sum scores could then be statistically tested against each other. We were hoping that twelve items (one A4 page) were enough to get valid results on the one hand but also that, on the other hand, it did not take too long for the participants to fill it out. Also, we managed to borrow a sensor that could measure heat, humidity, CO2 level and volume to be able to assess how far attention depends on these factors, too.

During that time, we also decided on implementing our program through six different lectures delivered three times each, using the two different break concepts and the control in each lecture, with one half of the lectures with five-minute breaks and the other one with ten-minute breaks. We then started writing and talking to lecturers who might support us by letting us implement our concepts in their lectures. Moreover, we found a fitness trainer to help us with the physical activity break.

All in all, during this phase of the project, we tried to make sure that our plans for the implementation phase were as detailed as possible, so that the actual execution of the project would work smoothly and without any problems. On the third poster, we summarized not only the results of this detailed planning phase but also of our whole project so far. ■



TUM

Quintessence
the project

Literature Research — Nov. 2018 – Apr. 2019

Case Studies — May 2019

Planning — Jun. – Sep. 2019

Study — Nov. – Dec. 2019

Evaluation & Impact — Jan. – Oct 2020

ABSTRACT

METHODOLOGIAL APPROACH

MAIN RESULTS

IMPACT & SUSTAINABILITY

PARTNERS & SUPPORTERS

- TUM Junge Akademie (tutor, supervisors, administrative support)
- TUM (participants in our study, see Tab. 1)
- ETH Zurich (Dept. Educational Development and Technology)
- RWTH Aachen (Dept. University Sport)
- TUM ProLehre

SEPTEMBER 2020

MEMBERS	Daniel Frey, Simon Gandorfer, Sophia Hasbach, Dennis Huber, Saskia Hutschenreiter, Jonas Papazoglou-Hennig
TUTOR	Sebastian Kaltenbach
SUPERVISORS	Dr. Susanne Witzgall, Prof. Dr. Hans Förstl

10 Jahre

inspired by TUM: Junge Akademie

POSTER 4: Shortly after the third poster, we started our six-week implementation phase. We attended each lecture with two of our team members plus the fitness trainer for the physical activity breaks as he carried out the mobility program. As already mentioned, we planned everything in a very detailed manner and therefore there was not much to do for us during this phase except for attending the lectures and making sure that everything worked smoothly there.

As this phase took place shortly before the Christmas holidays, we decided to make a start on evaluating our results only after the holidays. We then assessed our data by testing if there were statistically significant differences between the sum scores (^= attention) of the different concepts and lengths. Also, we tried to figure out how the environmental data related to the sum scores. Our results were promising, and we started documenting them for the project book by splitting the different parts between our team members. On poster 4, we then tried to summarize our goal, our concrete project, our results and what we were hoping to achieve with our project, thus making the poster a brief summary of the key elements of our project. ■

study strats

Project Report **StudyStrats**

Team	Elena Denise Tangocci Friederike Jungmann Katharina Johanna Wagner Kilian Lupp Lea John Samuel Valenzuela
Tutors	Konrad Weiß Martin Zirngibl
Supervisor	Prof. Dr. Azzurra Ruggeri

Preface by the Supervisor 180
Journalistic part 181
Scientific part 184
Self reflection 192
Posters 194

Preface by the Supervisor

Prof. Dr. Azzurra Ruggeri

What is the best way to study and learn? Not all students would agree on the same answer, and probably some would not even know how to answer in the first place. Indeed, students at the university can learn in a multitude of different ways: Some prefer attending lectures and taking notebooks after notebooks of notes, others prefer watching videos on the topic; some prefer reading books and others prefer learning through interactive group activities. But *preferring* a certain learning style doesn't necessarily make it the most effective. Which leads us to the Team's main research question and goal: Are different students most effective with different learning styles? Do students know which learning style is most effective for them? And, crucially, are there certain characteristics or traits that would allow us to predict which method is most beneficial for a student, and can we use this research to develop a tool that advises students on which learning style would work best for them? There is an important lesson for teachers and educators to learn from this project: We need to account for the different ways students learn, and give them opportunities to study and learn how it suits them best. In this sense, it is crucial to help students realize which way works best for them.

This has been a very ambitious and potentially impactful project, and the team worked really hard and was able to get first answers to all these questions. I really want to thank this group of amazing and enthusiastic students – motivated, creative, curious, smart and insightful. It has been such an amazing journey! I am sure they will do great with their studies, and I wish them all the best for their future careers. ■

Supervising the team StudyStrats of the TUM: Junge Akademie

Prof. Dr. Azzurra Ruggeri is the supervisor of the team StudyStrats of TUM: Junge Akademie. She heads the research group iSearch – Information Search, Ecological and Active Learning Research with Children – at the Max Planck Institute for Human Development in Berlin. There she investigates how children actively learn and how they manage to acquire knowledge about the world quickly and efficiently. Since 2017 Prof. Ruggeri is Professor of Cognitive and Developmental Psychology at the TUM School of Education.

Elena Tangocci and Lea John have been scholarship holders of TUM: Junge Akademie since November 2018 and members of the team StudyStrats together with Friederike Jungmann, Katharina Wagner, Samuel Valenzuela and Kilian Lupp.

1. Prof. Ruggeri, how did you come to the TUM: Junge Akademie?

R: Last year there was an event at the Technical University of Munich (TUM) where they introduced a new faculty. In addition, there was an introduction of programs and activities offered to TUM students. The TUM: Junge Akademie presented themselves at this event. As I wanted to find a way to serve the TUM community and TUM: Junge Akademie was the kind of program I felt I would like to be engaged in, I made myself available. I got in right away because it was already October – just a couple of months before you guys started the program.

2. The teams of the TUM: Junge Akadmie have come together under different headings. When our team – StudyStrats – was formed, we focused on the topic perception, attention, and interest. Afterwards the supervisors and scholarship holders came together to choose a team. What was your motivation to supervise our team?

R: I felt at some point that the group would converge onto something that I would find interesting. I could already feel it in the air that your idea would be close to what I am doing and what I am into. Besides that, I always look more for team composition than for expertise. I did not really care at the beginning what kind of topic we would converge on. It is more a matter of finding a group you are happy to work with. I had the impression that it was a good group. And Martin, the tutor of the team, helped convince me to supervise the team StudyStrats. He asked me if I wanted to work with you and I said: "Sure, why not?" I think at this point the group was more important than the topic. I was sure it would be easy to find something that we all converge on and that we all like and are happy with.

3. We, as a group, also came together because we really liked each other and could imagine working together on a topic. The scholarship program started in November 2018 and will end in a few months. During this time, you have worked with StudyStrats and have been in constant exchange with them. How was your experience working with the team StudyStrats?

R: I was happy about the team dynamics. I always had the impression it was a very motivated group of students who were very happy to work together. Experiences like this are one of the most important things you learn with the TUM: Junge Akademie. It is not just about publishing a paper, it is more about the experience: working together, finding something that everybody likes, and finding a way to grow together. I think that happened in your team and there was always lots of motivation and lots of professionalism. I really did see the group growing and this has nothing to do with the topic itself or how the project might turn out being. Even with the difficulties we might have had, like not being an actual research team, I definitely have more than positive vibes about the team. I think it is a group of people who care about each other and are passionate about research and this is much more important than the result itself in this case. Too often people misunderstand the goal of such a program, and I think the team never did.

4. ***As the head of the research group iSearch you deal every day with active learning research with children. Team StudyStrats engages in extensive research on active and passive learning. Can you explain in a nutshell what active and passive learning is about?***

R: That is a one-million-dollar question. To understand active learning in absolute terms there are different kinds of definitions produced. I think the best way to look at this is to think of a continuum between something that is completely passive and something that is completely active in every possible respect. The only thing you can do is to define what you mean with active and passive and what kind of factories you are considering at the moment. For example, in our project it is about how active an individual is when studying something, but we are not talking about manipulating or checking how physically active students are when studying something. When other researchers talk about active learning they might think of learning while being physically active, like moving around. Being physically active as a way to be more cognitively active. And there is some sense to it. It is just another valuable definition of what active learning is. So somehow there are different ways to look at active learning and I think the best way to see this is as a landscape in which you are considering different levels of activity and different parameters you can measure activity on. But it is just not possible to come up with a clear definition of what active learning is as it is a relative definition.

The opposite – the other side of the continuum – is passive learning. So whatever definition you end up focusing on in terms of active learning becomes by contrast the definition of passive learning.

5. ***The incentive of StudyStrats to engage in active and passive learning was to make it easier for first-year students to study for their exams. As a professor you also teach first semester students. Therefore, you are very close when they write their first exams during their studies. What is your experience of how students prepare themselves and how they manage the amount of material they learn?***

R: I try to do all my lectures and seminars at university with active learning which means they are interactive but in a flexible way. The attempt is to let the students be free to approach studying as they want. I like the concept of a flipped classroom: I give the material to my students and they can do the assignments whenever they want. Most of the assignments I give are active learning assignments: The students basically choose their topic in which they can do their research however and whenever they want.

I think the key is to give students the possibility to navigate through learning materials as they want to but obviously also to give them some anchors because not all students are happy with these very flexible methods. Some might get lost or they just do not know what they should be doing. Hence, as a teacher you want to offer them an 'act core template'. That brings us to one of the goals of your project.

In theory this is as successful as it can be. How effective this eventually is depends on many factors such as the student's motivation, the actual material, the implementation of material etc. Therefore, flexibility is important especially for institutions like universities with internationals, for students who study full-time or part-time, and for students who are not particularly good at German or English. There are a lot of barriers which make it difficult for students to follow a certain track which is rigid. The aim is to become more flexible and to give more possibilities than just teaching in front of a class.

6. ***As a former student, what was your experience during your studies at the University of Pisa regarding studying for exams? Did you immediately know from the first semester what strategy was the best for you while learning?***

R: I was basically preparing for exams by myself. I was – what students are not supposed to do – studying everything a week before the exams and then forgetting all of it afterwards. But I was also studying philosophy which is a difficult subject to learn in a more interactive way because it is mostly about learning what other people thought and wrote. Maybe they could have taught things in a different way like telling the students which authors to include in their studies. But where I studied it was very rigid and I do not do well with rigid things, so basically, I dropped out right away and did my own thing. But in the later semesters the system left some room for me and I could follow my own program and decided what classes I wanted to take and with whom. Starting then it worked much better for me.

7. ***What would you wish the team could achieve through their insights into learning strategies of first semester students?***

R: My hope is that we – or you guys – manage to get the answers you are after. I hope we are getting an insight into whether for example the rostrum strategies at university work better for some people but not for others. Based on this we can hope to be a little more effective and push students to become successful in their studies a little faster. Potentially, the developed tool is something that could be useful for teachers, professors or instructors knowing that not all students do similarly well with a certain way of learning. If we really find evidence that students learn better using different learning methodologies, we can give the professors something to work with.

8. ***The main findings of our study show a variance in performance among the different learning strategies. How do you believe this project should be continued? How can our findings be put in practice to improve learning strategies of first semester students?***

R: I think the first step is to test the tool in a control experiment in which we have people learning in different ways and then we see which way works best for each individual. Another thing is to go out and let people either study the way the tool says would be the best versus a way where our tool says it is not the best. The aim is to test all of this in a real world setting in which the things the participants are supposed to learn are really things that matter to them. For example, one module of class they are taking and material they have to study. Then it could be tested whether it makes a difference to study in a certain way or not. If this works in one way or the other, we can make this tool public. It is a way for people to learn about how to study better, something they might have not been able to achieve themselves. One of the things is that students sometimes do not know how they study better just because they have never been given the possibility to study in different ways. Some of them just do not know that there are other ways to study. With the tool we can offer them alternatives and show them which alternatives work best for them. The tool has potential to revolutionise teaching and learning at universities. ■

study strats

Table of contents:

Abstract

1. Background
  1.1 Introduction
  1.2 Personality
  1.3 Learning Style
  1.4 Learning Strategy

2. Method
  2.1 Project Aim, Research Question and Hypothesis
  2.2 Structure and Content of the Project
  2.3 Sample
  2.4 Design and Instruments
    2.4.1 Pilot Study
    2.4.2 Online Study
  2.5 Procedure
  2.6 Data Analysis

3. Outcome and Discussion
  3.1 Pilot Study
  3.2 Online Study
  3.3 Limitations

4. Summary and Further Work

References

Abstract

Knowing one's own best learning strategy is an important but challenging issue. In our research project, we created and validated a questionnaire tailored to determine what learning strategy would suit a student best. We predicted that the learning outcome is explained by students' learning preferences and is controlled by the scores of active and passive learning that our questionnaire calculated. For this, we conducted an online study with 102 participants who filled out the questionnaire and took three tests using different learning strategies. Our findings suggest that while there is a significant difference in test scores depending on the learning strategy, our questionnaire was not able to predict the most effective one accurately for each individual. Our results therefore align with other research disproving the meaningfulness of the VARK learning styles.

1. Background

1.1 Introduction

How to improve academic achievement? This question has engaged students and scientists for a very long time. Students are wondering how to perform well in classes like physics and history while scientists want to understand what learning actually is. But the current situation arising from the COVID-19 crisis and the global trend toward home- or online-schooling may change the meaning and realization of learning as it was understood before. Is every student able to attain their best results via online classes? Or is it the case that some students need to be actually present at school or university for an acceptable achievement, while others can easily gain knowledge by doing research or just simply reading scripts? How effective are online classes? We believe that effective learning is a synthesis between an individual's personality traits, learning style, learning strategy and some soft criteria like motivation, place of study etc. In the following the three main criteria are explained.

1.2 Personality

In questions of learning and attainment, personality matters a lot. This is why many scientists have created personality models over the years, like Corr and Matthews (2009), who established the OCEAN-model. This five-factor model explains very well the different characteristics of learning-related personalities. The model derives from the categories: Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism. "O-students" seem to be more intellectual, creative and interested in learning, while "C-students" have a lot of emotional control and self-discipline. The "E" of a student completely depends on the individual's age. "A-students" seem to be the better team-player while "N-students" show difficulties in handling challenges and stress. It was observed that Conscientiousness, low Neuroticism and Openness to a lower degree appear to be positive predictors of learning and achievement outcome, while Agreeableness and Extraversion have little or inconsistent effects on student learning and achievement (Corr & Matthews, 2009). This supports our assumption that different personalities will show a different outcome in academic achievement.

1.3 Learning Style

Relating to learning styles, there is a lot of confusion due to different ways of defining, measuring and diagnosing them. It is not even entirely clear that styles of learning affects academic achievement at all. It has to be mentioned that some scientists consider them as negligible (e.g. Jayakumar, N. et al., 2016; Kirschner, 2017). Other scientists attribute a higher role to criteria like responsibility and persistency than to learning styles (Synder, 1999). Nevertheless, we focused our project on the VARK learning style model by Fleming (2001, 2006). It is based on visual, auditory and kinesthetics (VAK) learning modalities and is supplemented by the components Read/Write. In this model, visual is defined as learning with eyes, like looking at videos or online classes as well as pictures and graphs. Auditory or aural is the style of learning with your ears which could mean group discussions as well as listening to explanations or music. Read/Write is the style of self-learning via texts and articles as well as writing, in general readers/writers prefer words as a source of knowledge. Kinesthetic is the method of learning through movements. This could be feeling and holding something as well as performing a speech, for instance (Othman & Amiruddin, 2010). It might be noted that the VARK learning style relates more to the means of acquiring information than to acquiring knowledge itself (Othman & Amiruddin, 2010). This fact makes the VARK model especially interesting at a time when methods of study have changed drastically in a short time, as we have all experienced during the first semester of the pandemic of 2020. A lot of universities changed to online classes, libraries were closed and some courses only provided articles and scripts as a learning source. Hence, we focused on the VARK model, even though it is criticized by some scientists as mentioned above.

1.4 Learning Strategy

The next criterion for effective learning is the learning strategy. A strategy is defined as a "sequence of procedures for accomplishing learning" (Schmeck, 1988). Hence, already in the past century it was clear that the strategy contributes to an effective way of learning. Many learning strategies can be found in the literature, all with different definitions and all characterize different forms of learners. Since the distinction between acquiring information in an active and a passive way is already well known in science and, as mentioned above, as access to relevant knowledge for students has changed drastically in 2020, we focused on active and passive learning strategies in our project. Active learning hereby means a bigger interaction with the learning material. In a passive way of learning the selection of learning material is limited and often predetermined (Gureckis & Markant, 2012). For us, a possible determinant for a passive way of learning can be the learning content as well as the learning pace. For instance, attending a lecture, online or not, is predetermined in terms of content and learning pace so it is a passive way of learning. Reading a given script for instance, that is often done during an online semester, is in fact passive in terms of content, but not determined in its learning pace. Hence this is herein an active strategy.

2. Method

2.1 Project Aim, Research Question and Hypothesis

In this research project, we aimed to help students find their most effective way of learning by creating a questionnaire-based advisor. It recommends how students can best learn by combining the criteria of personality and learning styles/strategies, which we claim are most relevant.

Research question:

To what extent does a diagnostic tool that matches students' learning preferences and personality characteristics to a learning modality (active and passive learning = reading scripts and handbooks, participating at lectures, conducting an online research) affect German speaking university students' learning performance?

- Hypothesis 1: The learning outcome of each session is explained by the students' learning preferences (recommended by the constructed survey).
- Hypothesis 2: Differences in test scores regarding learning modality are moderated by the covariates learning pace and learning content.
  - Hypothesis 2.1: watching a video is more effective if the questionnaire scale learning pace has a negative rating (passive in terms of learning pace) as well as the learning content (passive in terms of learning content)
  - Hypothesis 2.2: reading text is more effective if the questionnaire scale learning pace has a positive rating (active in terms of learning pace) and the scale learning content has a negative rating (passive in terms of learning content)
  - Hypothesis 2.3: online research is more effective if the questionnaire scale learning pace has a positive rating (active in terms of learning pace) as well as the scale learning content (active in terms of learning content)

2.2 Structure and Content of the Project

The project consists of four steps:

1) Piloting the adapted questionnaire, the developed learning sessions and knowledge tests for the online study A
2) Conducting the online study A to validate the questionnaire and the knowledge tests and to investigate if a variance on learning achievement is given among learning modalities.
3) Conducting the online study B to investigate the questionnaire correctness if recommending an appropriate learning modality with an experimental and a control group
4) Testing and implementing the advisor in real lectures

So far we have completed step 1-2 which is described in detail in the following sections. For clarification, we cannot directly affect the "soft criteria" like students' motivation or working place; with this questionnaire we do not guarantee students' achievement. The purpose of this tool is only to recommend and help students in need in order to find their best-fitting learning modality.

2.3 Sample

The sample of study A consisted of N = 138 volunteers who participated. Due to incomplete data a total of N = 102 participants were included in the analysis (61 female, 40 male, 1 diverse). The age of the subjects ranged from 19 to 43 years (Mage = 25.1 years, SDage = 3.8 years). In advance of study A, 14 subjects completed a pilot study on the basis of which the main study was designed.

The participants of study A were mostly students (95,1%). Exceptions were PhD students (n = 3) and chair staff (n = 2). The participants were asked about their professional background to be able to track bias in test results (see figure 1).

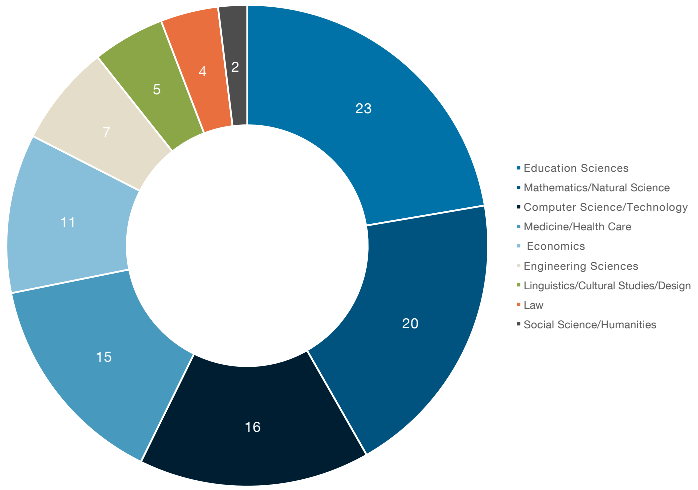


Fig. 1: Subjects by professional background (N = 102)

Since the study was in the German language, only participants with good German proficiencies (native speakers or CEFR-level C1+) were invited to take part in the study. All participants gave their written consent and were informed about data protection. The data was analyzed anonymously. The study was approved by the chief data privacy officer of the TUM.

Subjects were recruited from the following platforms:

- ORSEE (Online Recruitment System for Economic Experiments)
- Facebook Groups
  - Studien suchen Teilnehmer – Studienteilnehmer gesucht & gefunden (+ Umfragen)
  - Münchner Studenten
  - TUM: Junge Akademie
- LinkedIn
  - Internal group of TUM: Junge Akademie
- Instagram
  - TUM: Junge Akademie

2.4 Design and Instruments

The research project consisted of a pilot study with a questionnaire validation and an online experiment. After creating the questionnaire, three learning topics, each with a knowledge test, were chosen and developed. In order to validate the questionnaire and test the learning phases, a pilot study was run with acquaintances and family members. After adapting the findings to the study, we ran study A. Both were implemented and conducted in Qualtrics LLC.

2.4.1 Pilot Study

The whole study was tested and validated in a pilot study during the time period from 15.08.19 to 27.08.19 with 14 volunteers (5 female, 9 male; Mage = 25.0 years, SDage = 3.7) recruited by the StudyStrats team members within their personal environment. The volunteers were asked to give feedback after participating in the study. Following a guideline, the experimenter asked the participants open questions regarding the general comprehensibility, the structure and content of the questionnaire, the learning tasks and the knowledge tests. Depending on the information gathered in the pilot study the experimental design was optimized. Further, the tests were coded and the scores were analyzed in order to investigate the variance of the scores between participants. This procedure helped to adapt the knowledge tests.

2.4.2 Online Study

Study A is an experiment with a within-subject design. It consisted of three parts, which are described below:

Questionnaire

The questionnaire was created on the basis of previous research carried out by the team STUDYstrats. The research covered common, validated questionnaires regarding learning types such as VARK, personality traits, and active and passive learning strategies. It covered three categories. The first, active and passive learning, was divided into learning content (7 items) and learning pace (9 items). Three questions covered both. The second category comprised 11 questions of the VARK-model, and the third covered questions about personality traits (9 items). Further, personal information (4 questions), such as professional background, were added to the questionnaire. Participants had to answer all items of the questionnaire in order to proceed with the learning tasks.

Learning Tasks

We provided three different learning contents: visual system, brewing and living in space. Each learning content was structured based on three different learning modalities relating to active and passive learning: 1) listening to a "lecture" in a video (passive both in terms of content and learning pace), 2) reading a given text (passive in terms of content, active in terms of learning pace) and 3) individual online research (active both in terms of content and learning pace). The participants were encouraged to learn each of these topics within three 15-minute sessions. For each session, the system randomly assigned to the participant one of three modalities. In figure 2 the learning modalities are represented on a continuum from passive to active learning.

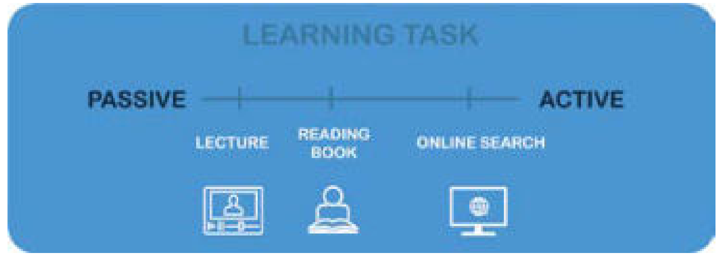


Fig. 2: Continuum of passive and active learning

All learning contents were created by the members of STUDYstrats. In the video, one of the members presented a topic simulating a lecture at university. The length of the videos ranged between 12 and 15 minutes for each topic. The texts of all three topics had nearly the same number of words (M = 1683, SD = 40.3). The video and text included the same content for each topic. For the online research, we provided a structure with keywords, on which the participant could build their search strategy. The keywords covered the same content as the other two learning modalities.

Each participant studied every content with one of the three learning modalities provided. Qualtrics randomly assigned each participant a learning modality for each learning session. The order of the session's topic was also randomized. An example of the procedure is given in image 2 for 3 people.

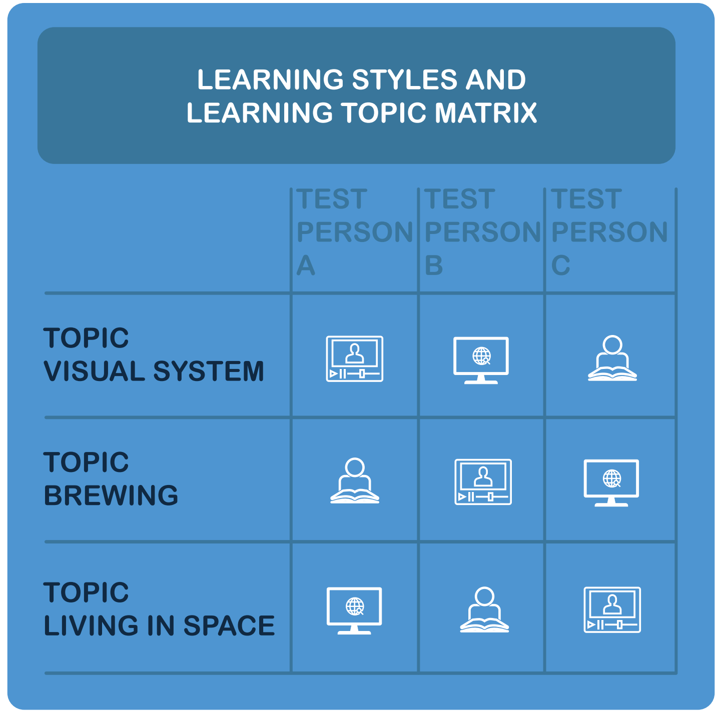


Fig. 3: Learning styles and learning topic matrix

Time for completion of the learning tasks varied between 11 and 17 minutes, depending on the content and modality.

Knowledge Test
After each learning session the subjects completed a knowledge test. Participants answered the test within a minimum of 2 minutes and a maximum of 10 minutes. Each test contained 10 multiple-choice questions. Each question answered correctly was allocated one point. Therefore, the maximum score was 10 points for each knowledge test.

2.5 Procedure

The link to the study was online between 23rd of December 2019 and 19th of January 2020. After recruiting volunteers from the platforms shown above, participants read the study information and data privacy on a separate link and sent us their consent via email. Afterwards, we replied to them with the link to the study. Each participant was asked to sit in a quiet space with good internet connection on their personal computer or tablet. The whole experiment lasted around one hour, in which each participant first answered the survey, then studied one learning session after the other and completed the corresponding knowledge test after each learning session. After finishing, the system generated a random numeric code, which each participant sent back to us. After checking the code, we paid a sum of 15€ for successful participation.

2.6 Data Analysis

The data analysis was conducted with SPSS and accomplished in three steps. First, the questionnaire's reliability was briefly analyzed with internal consistency analysis (Conbrach's Alpha). In a second step, we analyzed differences among topics when split by learning modality. Further, an analysis of covariance (ANCOVA) was conducted with the three factors and with three levels each – 1) learning content (visual system, brewing, living in space), 2) learning modality (video, text, online research), and 3) time of the learning session (first, second, third) and the two co-variants, learning pace and learning content – in order to investigate if the learning preferences recommended by the survey predicted the learning outcome (knowledge test scores).

3. Outcome and Discussion

In order to answer our research question, we validated the created questionnaire and analyzed the score differences between the three strategies used for the three learning sessions.

3.1 Pilot Study

Based on the interview during the pilot study, the examined questionnaire showed a good face validity. The participants could respond well throughout the pilot study, as there were no questions that could not be answered. Further, the participants correctly guessed the aim of the questionnaire and could understand what the questions were designed for. Items were excluded that were redundant or did not fit into the questionnaire. In total, twelve questions were excluded. Thus, the final instrument consisted of 30 questions (42 items).

For each knowledge test, two raters scored the answers of the open-ended questions. Inter-rater reliability showed an almost perfect agreement (K = .94). The following bar chart shows the scores in percentage for each test of each participant (n = 14). The results present a high variance between the learning strategies.

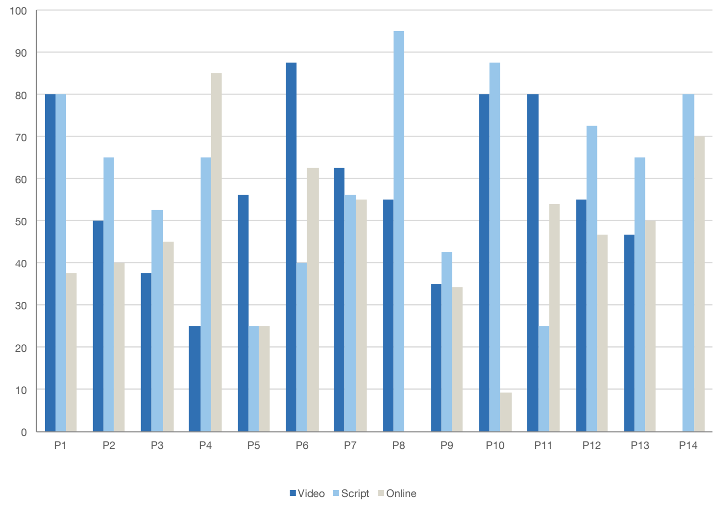


Fig. 4: Scores in percentage of the three learning strategies of each participant

For the online study A, we adapted the open-ended questions of the knowledge tests into comparable single- and multiple-choice questions with 10 items each, which facilitated the analysis during the online study.

3.2 Online Study

In a first step, to investigate the internal consistency of the questionnaire, we calculated reliability analysis. Cronbach's Alpha for the whole questionnaire was .557, which showed a weak internal consistency. This remained through all scales (see table 1).

Further, to test the first hypothesis, we investigated whether there is a significant difference between the scores of the learning topics divided by learning modality and ran an ANCOVA with the main effects mentioned above. Results show that there were significant differences among the main effect learning topic (see table 2). Participants differed from each other depending on the strategy used on the corresponding measurement point. These differences lead to the assumption that the knowledge tests have different difficulties.

Construct	Cronbach's alpha
Learning Pace	-.022 (due to negative average covariance among items)
Learning Content	.433 (weak)
VARK	.102 (weak)
Personality traits	.7 (acceptable)

Table 1: Reliability of the questionnaire's scales

The following figure shows a bar chart with the means and standard deviation of the strategies reading a script (M = 48.4; SD = 1.97), listening to a lecture (M = 49.5; SD = 1.97) and conducting an online research (M = 40.2; SD = 2.39).

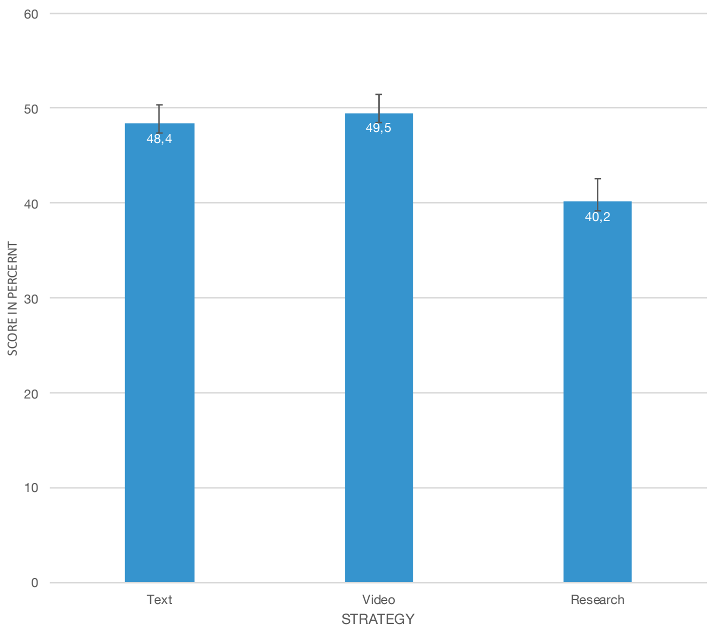


Fig. 5: Statistics of the three learning modalities

For further analysis, we excluded the main effect of time (at what point the learning session took place - first, second, or third), due to an insignificant difference. This means that the order in which participants learned the session does not have any effects on the learning outcome. In the next step, we found no significant difference in the main factor learning modality (see table 2), which demonstrates that the test scores did not differ based on the modality used during the learning session. Also the interaction effects between the factors did not show any significant effect. This first finding indicates that the used learning modality did not affect the test score of the specific learning session, which is not consistent with our first hypothesis.

To test the second hypothesis, we included as covariants the rates of the two active and passive questionnaire constructs learning pace and learning content. Results showed that there were no significant interaction effects on either learning modality and the two constructs. This could explain why the knowledge test scores based on the modality used during the learning session were not predicted by the values of the two constructs content and learning pace. Further, a frequency analysis showed a right-skewed distribution, which means that the majority of participants had more negative scores for both questionnaire constructs. This could be a reason for the insignificant interaction effects. Summarising, these second findings did not show a relation between the scores of the constructs content and learning pace with the learning performance of each of the three learning sessions. Thus, the questionnaire could not predict the most effective learning strategy for each individual. Therefore, we could reject our second hypothesis as well.

3.3 Limitations

Nevertheless, some limitations regarding our study should be mentioned. Due to the fact that the study has been conducted online, it could not be controlled in relation to whether or not the participants had spent the whole available time to deal properly with the learning topics. Moreover, no observations were made respecting their behavior while studying, including how they performed their online research. It also has to be noted that the test topics were not comparable in terms of detailed information. Based on the provided material and the test's questions, one topic might have been much easier than another. Further, prior knowledge was not measured, which could have affected participants' test scores.

4. Summary and Further Work

In our research project, we developed a questionnaire that recommends students' most effective learning strategy and tested the questionnaire within a pilot study and an online study, while evaluating two hypotheses: Firstly, that the learning outcome is explained by the students' learning preferences in terms of most effective learning modality, and secondly, that the learning outcome when studying with a certain learning modality is controlled by the questionnaire's passive and active learning scores of content and learning pace. Our findings reject both hypotheses. They suggest that there is no significant difference in test scores depending on the learning strategy, and that our questionnaire was not able to predict the most effective learning strategy for each individual. Our results align with other research disproving the meaningfulness of the VARK and passive/active learning styles. For instance, we approve Kirschner's theory that learning performance is not affected by learning styles and preferences, but, in fact, by other cognitive reasons, prior knowledge, motivation and the quality of the learning activity (Kirschner, 2017).

Cases	Sum of Squares	df	Mean Square	F	p	η^2_p
Topic	12.088.848	2.000	6.044.424	20.557	< .001	0.125
Learning modality	411.921	2.000	205.961	0.700	0.497	0.005
L.* Content	23.054	1.000	23.054	0.078	0.780	0.000
L. Pace	6.209	1.000	6.209	0.021	0.885	0.000
Topic X L. modality	1.052.650	4.000	263.162	0.895	0.467	0.012
Topic X Content	90.937	2.000	45.468	0.155	0.857	0.001
L. modality X Content	528.124	2.000	264.062	0.898	0.408	0.006
L. modality X Pace	691.199	2.000	345.600	1.175	0.310	0.008

Table 2: ANCOVA of the factors learning topic, learning modality, the covariates content and learning pace, and the interactions between the factors and covariates

* L. = learning

For a deeper analysis, the questionnaire will have to be modified and evaluated further. This includes the removal of some of the questionnaire's items to improve its internal consistency determined by a factor analysis. Further, moderation analysis should be run with the other constructs of the questionnaire. In a next step, another study could be conducted for further verification. We suggest the implementation of an experimental group, to which we assign the learning strategy based on the questionnaire's result, as well as a control group, to which we assign a random strategy not matching the questionnaire's recommendation.

This study contributes to research trying to help students find individual learning strategies with which they perform best. As the demand for this type of personalized guidance will stay highly relevant for students coming from less flexible learning environments, more studies should be conducted to find aspects which indicate the individual effectiveness of learning styles more accurately. Once more reliable correlations are found, a tool could be implemented which maps a student's answers in a questionnaire to one or more recommended studying approaches. ■

References

- Corr, P., Matthews, G. (2009). The Cambridge Handbook of Psychology, Cambridge University, Press, p. 734.
- Gureckis, T. M., & Markant, D. B. (2012). Self-directed learning: A cognitive and computational perspective. Perspectives on Psychological Science, 7 (5), 464-481.
- Jayakumar, N. et.al. (2016). Understanding Learning Style Variations among Undergraduate, Students, p. 5733.
- Kirschner, P. A. (2017). Stop propagating the learning styles myth. Computers & Education, 106, 166-171.
- Othman, N., & Amiruddin, M. H. (2010). Different perspectives of learning styles from VARK model. Procedia-Social and Behavioral Sciences, 7, 652-660.
- Schmeck, R. (1988). Learning strategies and learning styles. New York: Plenum Press.
- Snyder, R. F. (1999). The relationship between learning styles/multiple intelligences and academic achievement of high school students. The High School Journal, 83 (2), 11-20.

Self Reflection

Call 2019 – Multimodal science communication

How to communicate science? How to explain complex coherences? Scientific knowledge needs to be accessible as well as understandable. Nowadays, this is often not the case. “Multimodal science communication” was the theme of TUM: Junge Akademie in 2019.

Today, many important problems do not have disciplinary boundaries. Therefore, TUM: Junge Akademie provides a network where interdisciplinary teams develop new strategies to communicate science. New innovative solutions can create an impact on the communication of science in the future.

Team composition – StudyStrats

At the Kick-Off event, Dr. Sabrina Frankenberg and Elisabeth Raes gave input on the code of conduction, skills, personality, and roles in a team. Using exercises, they guided us through the process of choosing our topic and team. All members of StudyStrats remember a game in which each scholarship holder was evaluated on their team type. Similar team prototypes were assigned the same color. All of our future team members were assigned the same color and therefore the same team type. Our team of six scholarship holders was formed under the common topic “perception, attention and interest”, supported by our tutors Martin and Konrad as well as our supervisor Prof. Dr. Azzurra Ruggeri. Led by our vision and ideas we quickly organized the roles for each team member. For all of us, the team composition and “spirit” of the group dynamics were very important.

Workflow – How the project livened up

The shared vision and passion for the project dealing with concentration and attention in times of multimodal science communication and how perception works for the recipient in the digital age pushed us very far at the beginning. Our team (we named our project group StudyStrats) was quickly able to narrow down the topic of different learning types and to identify a clear structure of milestones. Due to everyone’s experience and previous scientific experience, we were able to create a detailed timeline for the next two years at the Junge Akademie.

Due to our good team spirit our meetings were not only dedicated to working but we also met regularly for social activities such as ice skating in winter, having barbeques and Italian dishes in summer accompanied by our team mascot, the unicorn Drölf. Motivation was always there, both for socializing and laughing with the other team members as well as working together on our project in an interdisciplinary manner. In Spring 2019, one of the highlights was to visit our supervisor Azzurra in Berlin for an intensive working weekend. We not only enjoyed the capital and visited the Max Planck Institute but were also able to structure the project in scientific steps. This weekend saw our project taking a big step forward.

Members studying a semester abroad were not an obstacle at all, but rather an enrichment thanks to interesting stories, stunning pictures, and unusual skype-meeting times due to global time differences. Everyone has enriched the project with their background knowledge, personality, interests, and ability to work in a team. Instead of putting themselves in the spotlight, everybody was considerate and caring towards the others and passionate about the project. Of course, there were times where we struggled to continue with the same enthusiasm and energy as in Berlin and at the Junge Akademie workshops. Everyone was doing their best for the project alongside many other commitments. All team members got to know their limits but were also able to grow, learn, and transcend their own discipline. We benefited from our widely spread disciplines like Brewing and Beverage Technology, Computer Science, Medicine, Health Science, Psychology and Architecture.

Progress and organization

The weekends with the TUM: Junge Akademie were highly productive because our team got the chance to present the project and get a lot of feedback from the other groups, alumni, supervisors and many other people. In summer 2019 there were phases when we met almost every week but also periods with less workload. Thanks to the clear allocation of roles, commitment and good lines of communication in StudyStrats we were well-organized and distributed work effectively among individuals and groups of two or three.

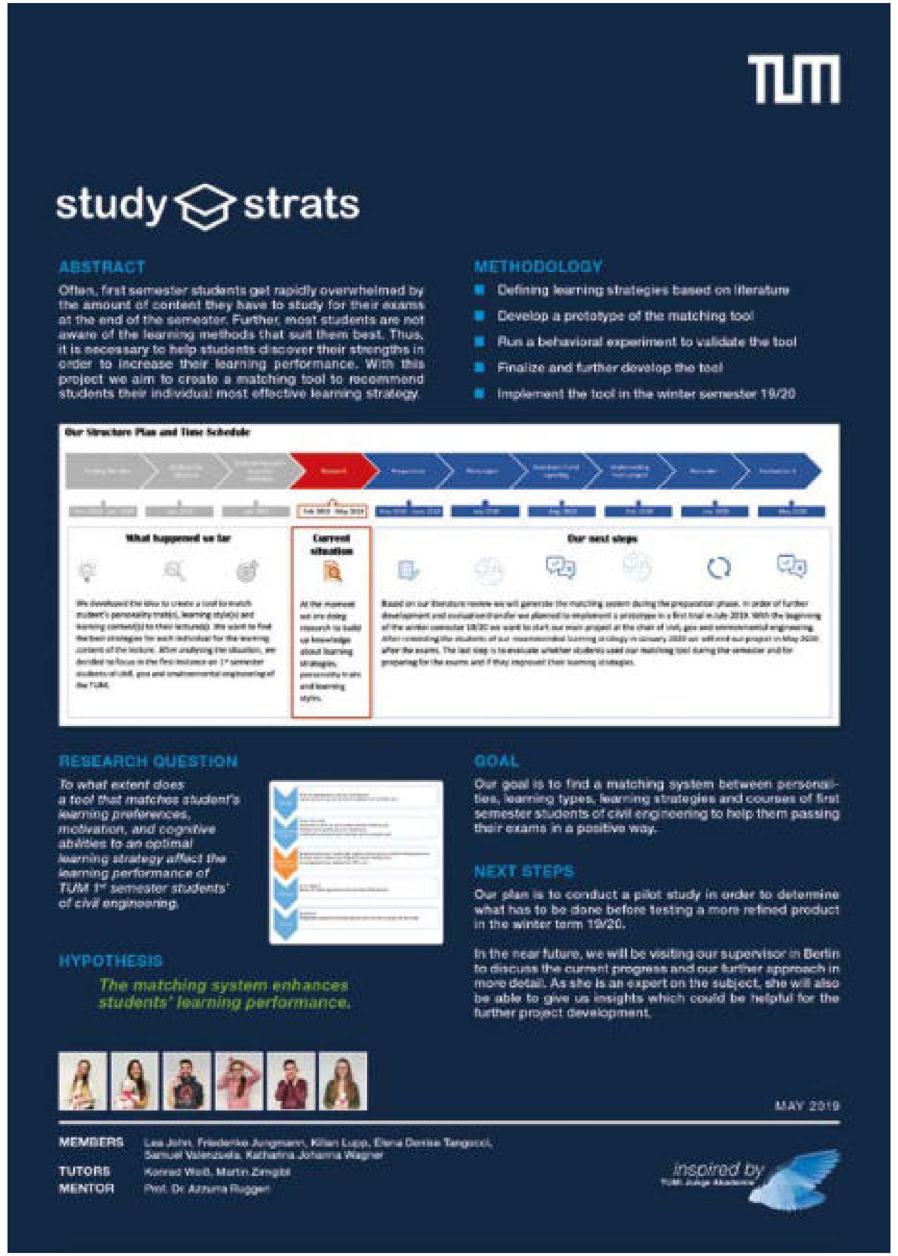
Since the Junge Akademie office and the University have been closed since March 2020 the corona virus has had an effect to our project meeting: We needed to move our meetings to the digital room. There were fewer meetings, but they lasted much longer than the usual weekly meetings. Unfortunately, the last workshop weekends with the TUM: Junge Akademie were cancelled. However, the office reacted quickly and we are still hoping for a symposium and official farewell for the teams of year 2019.

Summing up

Our project has investigated one aspect of multimodal science communication. It was an honor to be part of this fantastic team. Over the last two years all of us have grown together as a team and have become friends for life.

Of course, we could not have created our project without the great help of our supervisor Prof. Dr. Azzurra Ruggeri. Her valuable advice, in-depth knowledge and inspiring involvement was a huge asset to us. Furthermore, we would also like to thank her for making our survey possible and supporting us with all available means. Thank you very much!

We would also like to thank our tutors Konrad and Martin for their guidance, interest, and help. They have always been there for us, navigated us through the two years and always had the big picture of the project in mind. Thank you! ■



study strats

ABSTRACT

Often, first semester students get rapidly overwhelmed by the amount of content they have to study for their exams at the end of the semester. Further, most students are not aware of the learning methods that suit them best. Thus, it is necessary to help students discover their strengths in order to increase their learning performance. With this project we aim to create a matching tool to recommend students their individual most effective learning strategy.

METHODOLOGY

- Defining learning strategies based on literature
- Develop a prototype of the matching tool
- Run a behavioral experiment to validate the tool
- Finalize and further develop the tool
- Implement the tool in the winter semester 19/20

RESEARCH QUESTION

To what extent does a tool that matches student's learning preferences, motivation, and cognitive abilities to an optimal learning strategy affect the learning performance of TUM 1st semester students' of civil engineering.

HYPOTHESIS

The matching system enhances students' learning performance.

GOAL

Our goal is to find a matching system between personalities, learning types, learning strategies and courses of first semester students of civil engineering to help them passing their exams in a positive way.

NEXT STEPS

Our plan is to conduct a pilot study in order to determine what has to be done before testing a more refined product in the winter term 19/20.

In the near future, we will be visiting our supervisor in Berlin to discuss the current progress and our further approach in more detail. As she is an expert on the subject, she will also be able to give us insights which could be helpful for the further project development.

MAY 2019

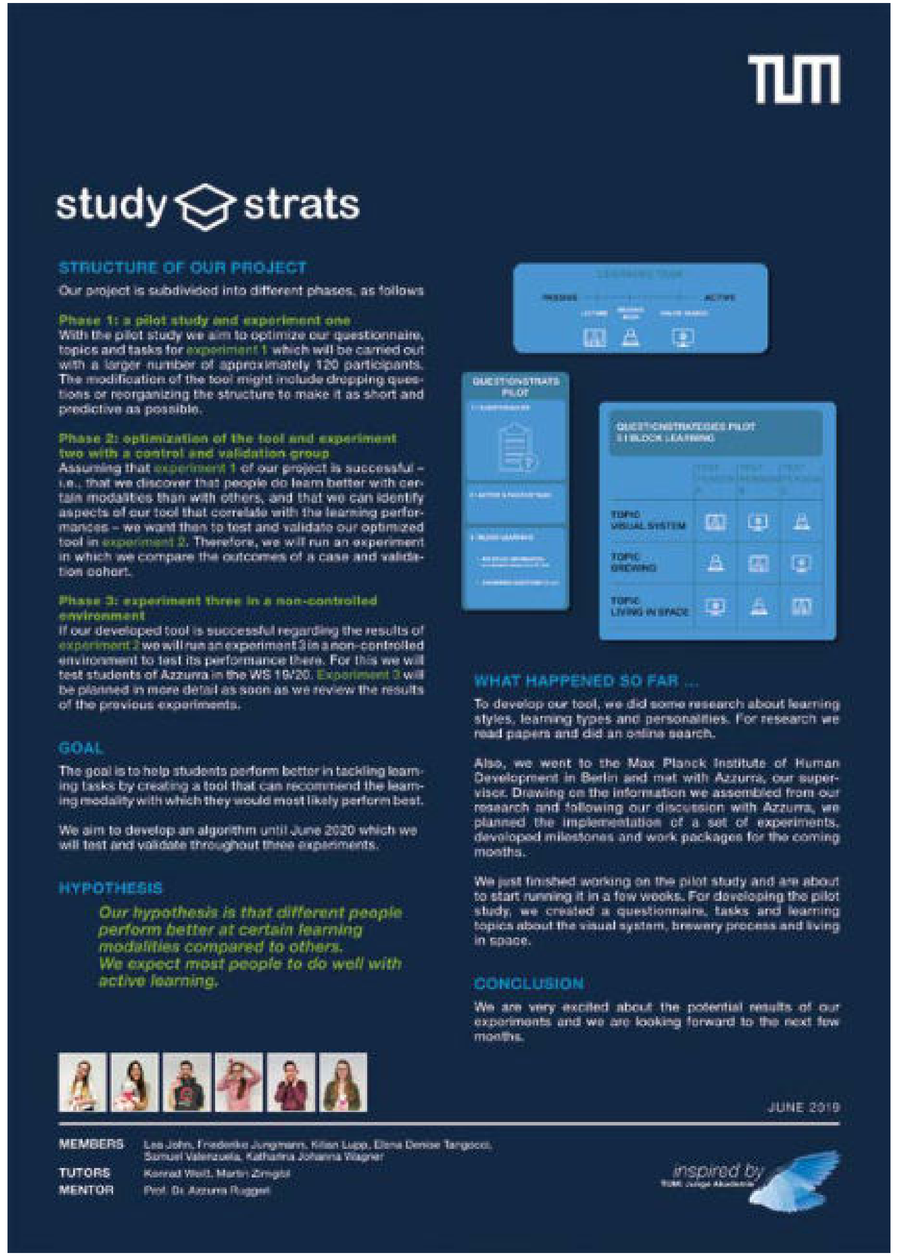
MEMBERS Lea John, Friederike Jungmann, Kilian Lupp, Elena Denise Tangocci, Samuel Valenzuela, Katharina Johanna Wagner
TUTORS Konrad Weiß, Martin Zirngibl
MENTOR Prof. Dr. Azzurra Ruggeri

inspired by TUM: Junge Akademie

POSTER 1: The first poster was sent in on April 2019, so at a very early stage of our project. For this we formulated an abstract about our claim that some students do not know about their individual and most effective ways of learning, and our aim, to create a matching tool with which we could recommend to students how to study best. Because we thought, and still think, that effective learning enhances the learning performance, a tool which helps to identify the individual's most effective way of learning will do so as well.

The methodology was already very clear: We had to research literature about learning in general and its different strategies; we had to create a prototype of our tool and evaluate it after a pilot experiment and eventually improve it. At this point we thought we would have enough time to implement our tool directly within the university's program. The timeline was clear as well as the approach. And for our research question we had to detail the final step, the implementation. We wanted to do this by creating the tool specifically for TUM 1st semester students of Civil Engineering and had therefore a further look at their studies and subjects. So, the pilot study had to be finished and evaluated before the start of the next winter semester (2019/20).

At this point we already knew that an intensive workshop with our supervisor, Prof. Dr. Azzurra Ruggeri, could be really productive, not only because she is employed at the Max Planck Institute for human development in Berlin and undertakes research about active learning with children, but also because we as a team would benefit from a workshop with no distractions. Thus, we planned to visit her in Berlin. ■



study strats

STRUCTURE OF OUR PROJECT

Our project is subdivided into different phases, as follows

Phase 1: a pilot study and experiment one
With the pilot study we aim to optimize our questionnaire, topics and tasks for experiment 1 which will be carried out with a larger number of approximately 120 participants. The modification of the tool might include dropping questions or reorganizing the structure to make it as short and predictive as possible.

Phase 2: optimization of the tool and experiment two with a control and validation group
Assuming that experiment 1 of our project is successful – i.e., that we discover that people do learn better with certain modalities than with others, and that we can identify aspects of our tool that correlate with the learning performances – we want then to test and validate our optimized tool in experiment 2. Therefore, we will run an experiment in which we compare the outcomes of a case and validation cohort.

Phase 3: experiment three in a non-controlled environment
If our developed tool is successful regarding the results of experiment 2 we will run an experiment 3 in a non-controlled environment to test its performance there. For this we will test students of Azzurra in the WS 19/20. Experiment 3 will be planned in more detail as soon as we review the results of the previous experiments.

GOAL

The goal is to help students perform better in tackling learning tasks by creating a tool that can recommend the learning modality with which they would most likely perform best.

We aim to develop an algorithm until June 2020 which we will test and validate throughout three experiments.

HYPOTHESIS

Our hypothesis is that different people perform better at certain learning modalities compared to others.
We expect most people to do well with active learning.

WHAT HAPPENED SO FAR …

To develop our tool, we did some research about learning styles, learning types and personalities. For research we read papers and did an online search.

Also, we went to the Max Planck Institute of Human Development in Berlin and met with Azzurra, our supervisor. Drawing on the information we assembled from our research and following our discussion with Azzurra, we planned the implementation of a set of experiments, developed milestones and work packages for the coming months.

We just finished working on the pilot study and are about to start running it in a few weeks. For developing the pilot study, we created a questionnaire, tasks and learning topics about the visual system, brewery process and living in space.

CONCLUSION

We are very excited about the potential results of our experiments and we are looking forward to the next few months.

JUNE 2019

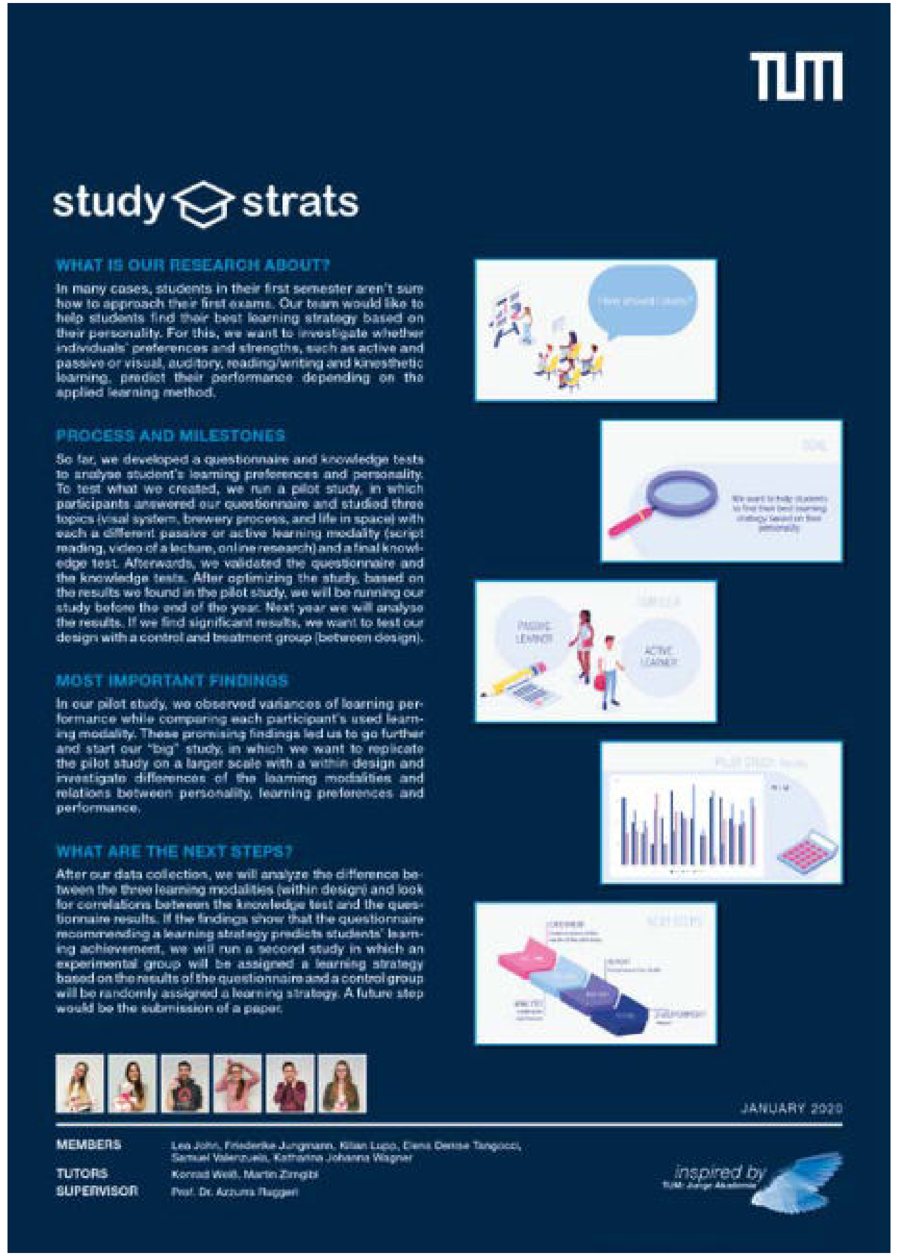
MEMBERS Lea John, Friederike Jungmann, Kilian Lupp, Elena Denise Tangocci, Samuel Valenzuela, Katharina Johanna Wagner
TUTORS Konrad Weiß, Martin Zirngibl
MENTOR Prof. Dr. Azzurra Ruggeri

inspired by TUM: Junge Akademie

POSTER 2: The second poster was published after our very productive weekend in Berlin. With guidance from our supervisor, we created a three-phase plan to optimize the final experiment for our project and consolidated its details. As you can see in the poster, step one was to optimize our study by doing a pilot study first. Hence, after creating and evaluating a questionnaire for our subjects, we could start experiment one with approximately 120 participants. Experiments two and three were then intended to follow a process of evaluation. But as we will see, we didn't have the time to run these two experiments.

Nevertheless, the structure of the experiments was quite clear: Each subject should do a test about three different topics, and the learning progress to pass the test should be a different one each. The three learning methods should be: as passive learning (learning within a lecture); as semi-passive-active learning (reading articles and similar material); and, eventually, as an active learning method (doing an online research). Therefore, we planned to record video-classes for each topic and to provide learning materials and to create a do-ability test within all three learning methods.

As you can see on the poster, our goal changed a little, as we went from a tool for students of civil engineering to students in general. The hypothesis also changed a little: We focused a bit more on the comparison of the different learning modalities than on the tool in general. ■



TUM

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WHAT IS OUR RESEARCH ABOUT?

In many cases, students in their first semester aren't sure how to approach their first exams. Our team would like to help students find their best learning strategy based on their personality. For this, we want to investigate whether individuals' preferences and strengths, such as active and passive or visual, auditory, reading/writing and kinesthetic learning, predict their performance depending on the applied learning method.

PROCESS AND MILESTONES

So far, we developed a questionnaire and knowledge tests to analyse student's learning preferences and personality. To test what we created, we run a pilot study, in which participants answered our questionnaire and studied three topics (visual system, brewery process, and life in space) with each a different passive or active learning modality (script reading, video of a lecture, online research) and a final knowledge test. Afterwards, we validated the questionnaire and the knowledge tests. After optimizing the study, based on the results we found in the pilot study, we will be running our study before the end of the year. Next year we will analyse the results. If we find significant results, we want to test our design with a control and treatment group (between design).

MOST IMPORTANT FINDINGS

In our pilot study, we observed variances of learning performance while comparing each participant's used learning modality. These promising findings led us to go further and start our "big" study, in which we want to replicate the pilot study on a larger scale with a within design and investigate differences of the learning modalities and relations between personality, learning preferences and performance.

WHAT ARE THE NEXT STEPS?

After our data collection, we will analyze the difference between the three learning modalities (within design) and look for correlations between the knowledge test and the questionnaire results. If the findings show that the questionnaire recommending a learning strategy predicts students' learning achievement, we will run a second study in which an experimental group will be assigned a learning strategy based on the results of the questionnaire and a control group will be randomly assigned a learning strategy. A future step would be the submission of a paper.

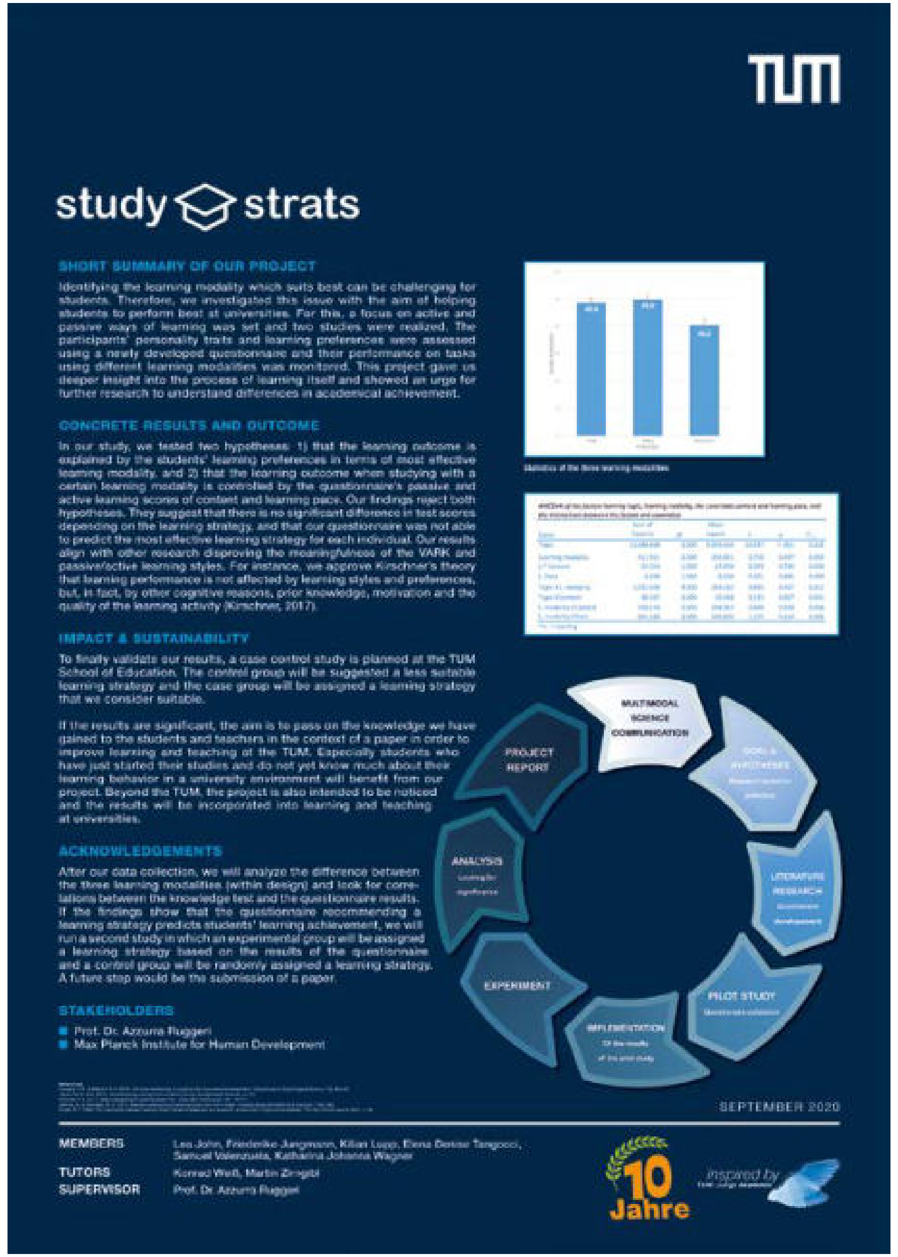
JANUARY 2020

MEMBERS Lea John, Friederike Jungmann, Kilian Lupo, Elena Denise Tangocci, Samuel Valenzuela, Katharina Johanna Wagner
TUTORS Konrad Weiß, Martin Zirngibl
SUPERVISOR Prof. Dr. Azzurra Ruggeri

inspired by
TUM: Junge Akademie

POSTER 3: The third poster was published in January 2020, right in the middle of our first experiment, so we could not show the outcome yet. The steps for running experiment one were carried out with great success, we recorded our classes, optimized the questionnaire and the test, and validated the experiment with a couple of selected subjects. Thus, a couple of project milestones had already been achieved. Indeed, our progress was so advanced, that we were able to give a precise overview of what our research was about in poster three.

As you can see, we had already gained some knowledge from the pilot study. We observed variations of learning performance while comparing each learning modality. This encouraged us to start experiment one as soon as possible. In our "next steps" we still mention an experiment two, but since time was already short, we could not plan to realize this before the end of the TUM: Junge Akademie. Rather, we planned to stay together as a team after our official project ended in order to fulfil our task. Nevertheless, our goal and hypothesis had not changed since poster two. ■


MULTIMODAL SCIENCE COMMUNICATION
GOALS & HYPOTHESES
LITERATURE RESEARCH
PILOT STUDY
IMPLEMENTATION
EXPERIMENT
ANALYSIS
PROJECT REPORT

TUM

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SHORT SUMMARY OF OUR PROJECT

Identifying the learning modality which suits best can be challenging for students. Therefore, we investigated this issue with the aim of helping students to perform best at universities. For this, a focus on active and passive ways of learning was set and two studies were realized. The participants' personality traits and learning preferences were assessed using a newly developed questionnaire and their performance on tasks using different learning modalities was monitored. This project gave us deeper insight into the process of learning itself and showed an urge for further research to understand differences in academical achievement.

CONCRETE RESULTS AND OUTCOME

In our study, we tested two hypotheses: 1) that the learning outcome is explained by the students' learning preferences in terms of most effective learning modality, and 2) that the learning outcome when studying with a certain learning modality is controlled by the questionnaire's passive and active learning scores of content and learning pace. Our findings reject both hypotheses. They suggest that there is no significant difference in test scores depending on the learning strategy, and that our questionnaire was not able to predict the most effective learning strategy for each individual. Our results align with other research disproving the meaningfulness of the VARK and passive/active learning styles. For instance, we approve Kirschner's theory that learning performance is not affected by learning styles and preferences, but, in fact, by other cognitive reasons, prior knowledge, motivation and the quality of the learning activity (Kirschner, 2017).

IMPACT & SUSTAINABILITY

To finally validate our results, a case control study is planned at the TUM School of Education. The control group will be suggested a less suitable learning strategy and the case group will be assigned a learning strategy that we consider suitable.

If the results are significant, the aim is to pass on the knowledge we have gained to the students and teachers in the context of a paper in order to improve learning and teaching at the TUM. Especially students who have just started their studies and do not yet know much about their learning behavior in a university environment will benefit from our project. Beyond the TUM, the project is also intended to be noticed and the results will be incorporated into learning and teaching at universities.

ACKNOWLEDGEMENTS

After our data collection, we will analyze the difference between the three learning modalities (within design) and look for correlations between the knowledge test and the questionnaire results. If the findings show that the questionnaire recommending a learning strategy predicts students' learning achievement, we will run a second study in which an experimental group will be assigned a learning strategy based on the results of the questionnaire and a control group will be randomly assigned a learning strategy. A future step would be the submission of a paper.

STAKEHOLDERS

- Prof. Dr. Azzurra Ruggeri
- Max Planck Institute for Human Development

SEPTEMBER 2020

MEMBERS Lea John, Friederike Jungmann, Kilian Lupo, Elena Denise Tangocci, Samuel Valenzuela, Katharina Johanna Wagner
TUTORS Konrad Weiß, Martin Zirngibl
SUPERVISOR Prof. Dr. Azzurra Ruggeri

10 Jahre

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TUM: Junge Akademie

POSTER 4: We handed in the fourth and final poster after finalizing the project report in September 2020. In this poster, we mainly present the insights we gained by conducting the main study. After having received 102 submissions, we closed the online survey and started analyzing the collected data to evaluate two hypotheses: Firstly, that the learning outcome is explained by the students' learning preferences in terms of most effective learning modality, and secondly, that the learning outcome when studying with a certain learning modality is controlled by the questionnaire's passive and active learning scores of content and learning pace. In the end, both of these hypotheses were rejected.

As a concrete idea for possible future work, we suggested a final validation of our results with a case study at the TUM School of Education. In that additional study, the participants would be split into two groups, where one group studies a topic with the suggested learning strategy, while the other group uses another learning strategy. If meaningful results were to emerge from this, the plan would be to publish a paper in which the findings would be presented. Another goal would be to incorporate the results into learning and teaching at universities.

Finally, we would like to thank the following people, who have supported us throughout all stages of our project: First and foremost, our project would not have been nearly as successful, without the invaluable input by our supervisor Prof. Dr. Ruggeri, whom we express our sincere gratitude. Furthermore, we would like to thank Peter and Maria from the Junge Akademie office, as they always were very encouraging and offered their full support whenever necessary. Last but not least, thank you to Konrad and Martin, our tutors who guided us from beginning to end and with whom we experienced numerous joyful moments. ■

Highlights 2019

Photo Gallery 200

Kick-Off weekend at Lake Starnberg

PIXIDA Workshop

TUM running group at English Garden

Team ClusterMe presentation

2018

2019

November December January February March April May June

The organizers of our first Science Hack!

First FutureLab – Bad Tölz

Visit VRlab@Deutsches Museum

Alumni2Newbies-event

Bicycle Service Station at campus Freising

Street Science @ Streetlife Festival

Visit at the Imperial College London

Second FutureLab in Dachau

2020

July August September October November December January February

Mentoring Kick-Off

Selection days 2020

Organizer-team of the 2. Science Hack

Deutschland Stipendium ceremony

TUMJA visits Kammerspiele

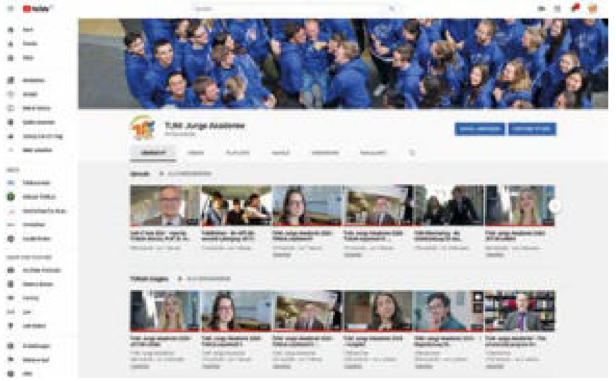
Advisory Board electing the call 2020

5. Call 2020 - Vorschläge
TUM

Workshop at PIXIDA

Intermediate Evaluation Year 2020

March April May June July August September


TUM: Junge Akademie

JATUM goes YouTube

Image video TUMJA

Running picnic by taskforce event

Projects in Prospect 2020

AppCycle 208
Clarify 210
EnterTrainment 212
Exfluenced 214
Exhibition Fish 216
Lacktivity 218

AppCycle

Background

Nowadays humanity consumes a huge amount of fossil fuels to maintain the standard of living and produce its consumption goods. As consequence of the matter, too much waste is produced. Nature suffers - humanity acts ignorant. Different studies proof the increasing waste production on the entire planet, even in well-developed countries such as Germany.

Why does humanity behave this way? What has to be improved to reduce waste production? How can people be reached and convinced to change their waste management? As it turned out in the first team gatherings, all of us were seriously concerned with and interested in these questions, although we are all engaged in very different fields of studies. In the context of “TUMJA” we got to know each other, found this severe environmental concern of ours and decided to team up for developing an artsy project to improve humans’ rate of waste consumption. The optimal waste management can be pictured with the so called “waste pyramid” (see Figure 1): For nature the most favoured option is prevention of waste, which is on top of the pyramid. If avoiding waste is not possible, the actions reducing, reusing or recycling should be chosen. On the bottom one can consider disposal as the least favoured option of waste management.

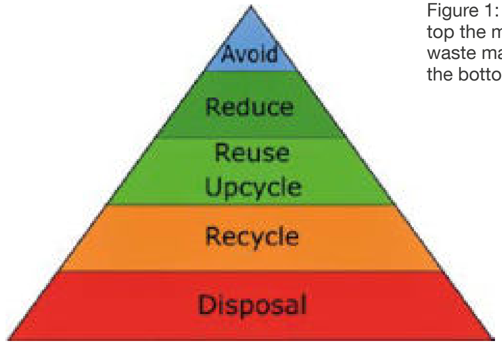


Figure 1: Waste pyramid. On the top the most favoured option of waste management is shown,on the bottom the least favoured one.

Goal

After doing research and contacting different companies and professionals who have gained experience in the field of waste management, we draw the conclusion that many possibilities for re- and upcycling already exist. However, there is a crucial lack of actions and habits in people’s lives regarding re- and upcycling. The main reasons therefore are the lack of knowledge, laziness and the immense effort to find the above mentioned possibilities and information. Based on the outcomes of our research, we came up with the following goal: “Team AppCycle will create an app until December 2020 with 500 downloads by the end of the project phase to integrate re- and upcycling into lifestyle and change habits towards a more sustainable behaviour.” The app (logo see Figure 2) will simplify gathering information, especially about artistic upcycling projects, and further encourage the users to keep track of their waste consumption.

Figure 2: The logo of our app.

The functions of AppCycle

The app will provide an interactive map of Munich, where for example recycling stations, repair cafés, eco-friendly shops, etc. can be found. Additionally, there will be a calendar, that contains information about interesting events such as flea markets or exhibitions regarding environmental topics. The centrepiece of the app is going to be a newsfeed where users can share their ideas for upcycling as well as like and comment on other posts. This way, the user can easily reach out for possibilities reusing one’s waste instead of throwing it away. Since those ideas lead often to the production of artistic gadgets out of former waste, the newsfeed also links AppCycle with this year’s call “Technology and Arts”.

Time schedule

After doing research, determining our goal and arranging the functions as mentioned above (see Figure 3), we created a mock-up of the app, which we demonstrated to different experts in order to receiving feedback. Currently we are using their responses for adjusting and specifying the functions, before the app itself is going to be developed in the next months. During that time, we will contact shops and other project partners as well as evolve a marketing plan for the App-Launch. In October 2020 we plan to implement the app for a test group before finally launching it in December. In the beginning of next year, feedback and surveys from users will be gathered for improving our app and collecting data that contributes to solve/improve the waste consumption problem. At the end of the project phase, one important question has to be answered: What is the further destiny of the app? Who is going to keep the app updated? ■

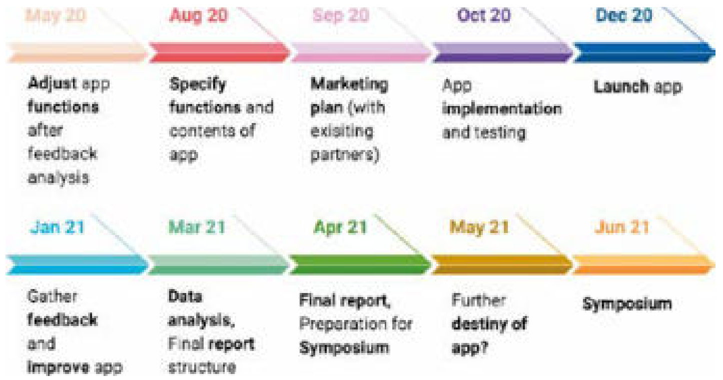

May 20
Adjust app functions after feedback analysis
Aug 20
Specify functions and contents of app
Sep 20
Marketing plan (with exisiting partners)
Oct 20
App implementation and testing
Dec 20
Launch app
Jan 21
Gather feedback and improve app
Mar 21
Data analysis, Final report structure
Apr 21
Final report, Preparation for Symposium
May 21
Further destiny of app?
Jun 21
Symposium

Figure 3: Project Timeschedule.

Team

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Ario Dastmaltschi
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Maximilian Passek
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Bernhard Häfner

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Dr. Jan-Hendrik Passoth
Dr. Susanne Witzgall

Clarify: A Case for Inclusion

Background and Update

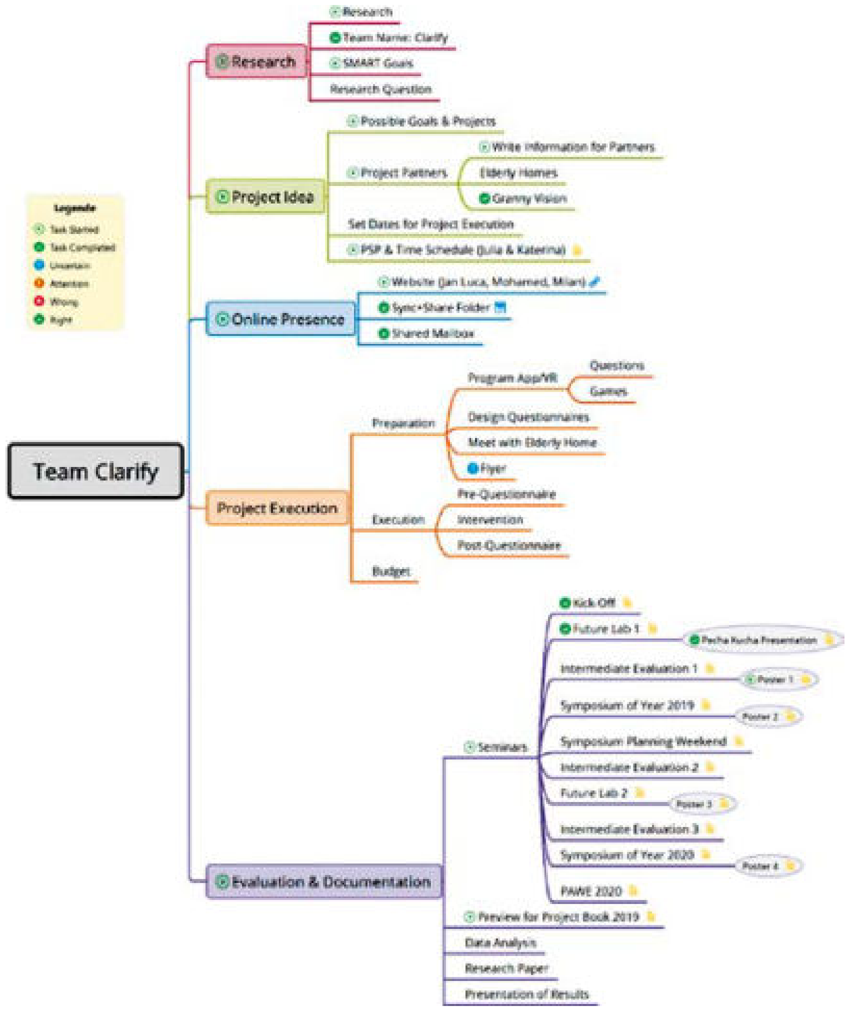
We are a research group from diverse backgrounds who are eager to change perceptions about scientific issues and create enthusiasm for them in accordance with this year's call. This sparked our initial research phase where we found that art was frequently used in science communication and that the elderly were a promising yet relatively unexplored target group. We've since been in contact with companies that had extensive experience with reaching the elderly and gathered a list of contacts. Our aim is to use modern technology and the appeal of the arts to make senior citizens more open to using it and feel more aware of recent developments. Currently, we are working on summarizing our research results and developing the method before transitioning into contacting elderly homes.

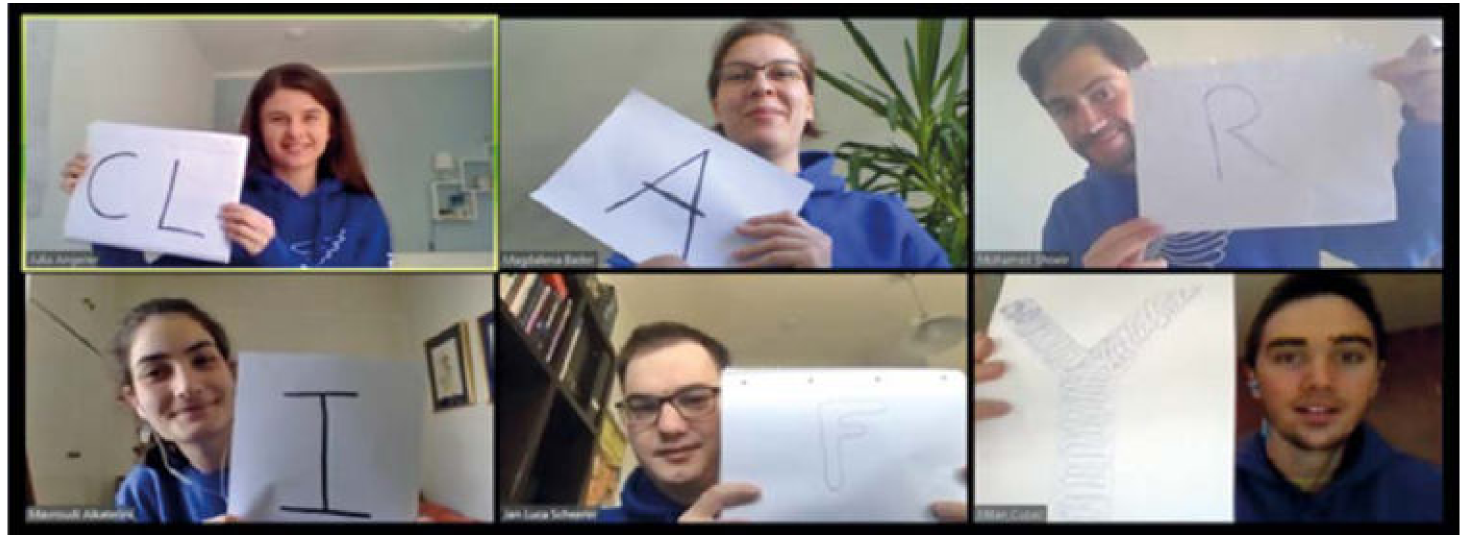
Methodology

Our primary method is the use of virtual reality headsets where an art form is presented and provides an exciting experience (e.g. a museum tour) and a way to fully experience the arts from home. The alternative will be a mobile application where a battery of science questions as well as mental agility exercises are offered as a quiz and throughout which we will be present virtually. The precise methodology will largely depend on logistical issues and constraints of the current situation, but our goal will remain the same. We will then distribute questionnaires that accurately measure our chosen constructs and have found the most support in the literature.

Dealing with COVID-19

Our project is directed at senior citizens and although we are faced with uncertainty, we believe that the adjustments in our methods will help us reach our target audience without our physical presence. We also hope that the participatory aspect will include individuals who are deeply isolated during this time and will provide an enjoyable experience as well as relief. We are closely monitoring developments and understand that in reaching our target audience (as well as any other), timing is extremely important and are always ready to readjust. The current pandemic is not extraordinarily affecting our teamwork. As we have been working with Skype calls before due to stays abroad, we got used to online meetings pretty quickly. Although we can't meet and exchange physically, we are still having fun online!


Legende
Task Started
Task Completed
Uncertain
Attention
Wrong
Right
Team Clarify
Research
Research
Team Name: Clarify
SMART Goals
Research Question
Project Idea
Possible Goals & Projects
Project Partners
Write information for Partners
Elderly Homes
Granny Vision
Set Dates for Project Execution
PSP & Time Schedule (Julia & Katerina)
Online Presence
Website (Jan Luca, Mohamed, Milan)
Sync+Share Folder
Shared Mailbox
Project Execution
Preparation
Program App/VR
Questions
Games
Design Questionnaires
Meet with Elderly Home
Flyer
Execution
Pre-Questionnaire
Intervention
Post-Questionnaire
Budget
Evaluation & Documentation
Seminars
Kick Off
Future Lab 1
Pecha Kucha Presentation
Intermediate Evaluation 1
Poster 1
Symposium of Year 2019
Poster 2
Symposium Planning Weekend
Intermediate Evaluation 2
Future Lab 2
Poster 3
Intermediate Evaluation 3
Symposium of Year 2020
Poster 4
PAWE 2020
Preview for Project Book 2019
Data Analysis
Research Paper
Presentation of Results



Goals and Hypotheses

Goal:
We want to significantly increase the openness towards new technologies of the residents in two retirement homes and facilities for assisted living by January 2021, through the presentation of artistic content via VR.

- The residents will be presented artistic content such as painting-classes or tours of different museums.
- The residents will fill in questionnaires about alterations in their openness towards modern technologies before and after the VR-sessions. We will evaluate these questionnaires to measure the change.
- We will also measure constructs related to wellbeing (positive affect, perceived competence or enjoyment) as well as other responses e.g. appreciation and engagement with science or art

We predict that the transmission of art through modern technology can serve as an effective communication tool and facilitate our project goals.

Cooperation

Do you have any ideas of your own?
Would you like to cooperate with us?
Feel free to contact us at: clarify@ja.tum.de ■

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Silke Schmidt
Prof. Dr. Michaela Krützen (consultant)

EnterTrainment

Background

For a long time, Munich was on place number one for being the German city where motorists spent most time in traffic jams. Traffic pollution leads to bad air quality and is a major cause for climate change. One of its effects is extreme weather, which leads for example to health issues and problems for farmers; the higher temperature allows the atmosphere to be more humid and reduces the frequency of precipitations. Scarcity of drinking water, damage of vegetables and grains as well as alterations in the production of milk are only some of the consequences. In the evaluation of the “Bundesländerindex Mobilität & Umwelt” of 2018/2019, Munich received the lowest qualification for “Climate Protection”, which contemplates the amount of CO2 emissions from traffic per inhabitant. This shows us that there is still much to be done to improve our city’s contribution in fighting climate change.

Project Goal

In sight of the current situation, we decided to do our part in making Munich eco-friendlier and contributing to the reduction of carbon emissions in our city. Said concretely, we aim to raise consciousness about transportation habits and their impact on the environment among the young adult population in Munich by June 2021. To accomplish this, we have the following sub goals:

- Conduct a behavioral intervention via a mobile app
- Keep frequent users engaged with the public transport system
- Encourage occasional users to become frequent users

To measure the success of our project, we will conduct surveys before and after executing the intervention, both in a control group as well as among the individuals who were exposed to targeted feedback and other kinds of incentives.

Research Question

Are targeted feedback and other incentives more effective than general recommendations to influence users towards ecofriendly behavior with respect to transportation habits?

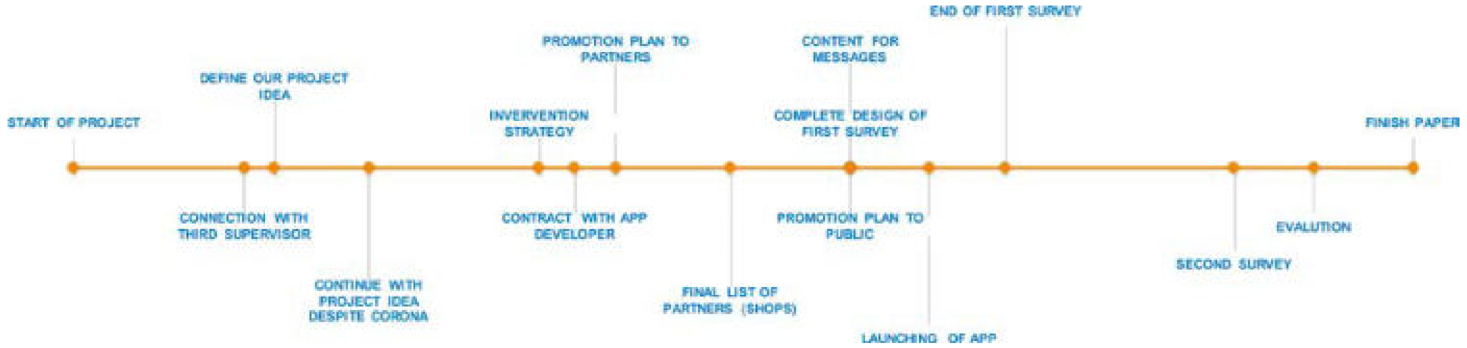
Hypothesis

According to our preliminary research, behavior can be changed by conducting an intervention and correctly addressing the user’s motivations. We expect this to also be the case for influencing transportation habits and hypothesize that the effectiveness of the intervention depends on the kind of incentive to which the individual is exposed.

Methods

As mentioned in the description of our project goal, we will conduct an intervention study with the objective of motivating users to travel by ÖPVN. The following incentives will be tested:

1. Targeted eco-feedback. How much CO2 is the user saving by using ÖPVN compared with the same trajectory by car?
2. Reward system in partnership with local shops where users can exchange their saved CO2 for discounts
3. Social comparison of CO2 savings during a specific period. Where is the user in the rank of his district, age group, etc.? Where is the user’s district in the rank of Munich?
4. Accomplishment of personal commitments. How many times/days did the user travel by ÖPVN compared with how many times/days he intended to do so?
5. “Make-it-social” allowing the user to publish his progress in social media and get to invite friends to use the app


START OF PROJECT
CONNECTION WITH THIRD SUPERVISOR
DEFINE OUR PROJECT IDEA
CONTINUE WITH PROJECT IDEA DESPITE CORONA
INVERVENTION STRATEGY
CONTRACT WITH APP DEVELOPER
PROMOTION PLAN TO PARTNERS
FINAL LIST OF PARTNERS (SHOPS)
CONTENT FOR MESSAGES
COMPLETE DESIGN OF FIRST SURVEY
PROMOTION PLAN TO PUBLIC
LAUNCHING OF APP
END OF FIRST SURVEY
SECOND SURVEY
EVALUTION
FINISH PAPER

Each incentive type will be added progressively to the study as the number of participants increases. It will be done this way to ensure that we have a large enough sample for each type.

Project Plan

The building blocks for the deployment of our project are…

- Research: this has been key to define the frame of our project and challenge our assumptions. Until now, we have focused on understanding our user and learning about nudging strategies to design and prepare the behavioral intervention. However, research will continue to be present in every phase of the project.
- Collaborations and partnerships: the collaboration with key actors, such as the MVV, the SWM and entities with similar aims as ours, like Greencity and the EU project "Mobility Urban Values" (MUV) are most important. In the same way, the realization of partnerships with local shops is essential for the operation of our reward system.
- Mobile app: all the way from concept to coding to launch, the development of the mobile app is one of the core building blocks because it is our first tangible outcome and the instrument to execute and test the intervention study.
- Behavioral intervention: based on principles of choice architecture and the results of our research about our potential users, the intervention describes the methodology being used in both our project and research.
- Measurement instrument and evaluation: the elaboration of the initial and final survey, the size of the samples and the analysis of the obtained results, among other criteria, will determine the validity of our study. For this reason, we are dedicating several work packages to ensure the quality of our scientific work.

Current Progress

We are currently searching a programmer to start with the development of the mobile app and working on the contents to be used as part of the behavioral intervention. We have also already met some of the organizations we want to collaborate with and will continue to work on this for the following weeks. In parallel, we are elaborating the material for our promotion campaign.

Collaborations and Partnerships

Would you like to collaborate with us and make Munich eco-friendlier and greener? If you enjoy putting to practice your coding skills or want your commercial business to be part of our reward system, we are looking for you! You can contact us to our email: entertrainment@ja.tum.de. Welcome to our team! ■

Team

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Jonas Unterholzner
Sarah Kluge
Jeremias Widmann

Tutors	**Supervisors**
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Victoria Tressel	Prof. Dr. Christoph Ungemach
	Prof. Dr. Jan Müller-Wieland

Exfluenced

Introduction

The last few years have seen a massive change in how people consume their social media feed. Focus shifted from pictures of friends' dogs and family and status updates to reading news, buying products, and following the advice of many self-proclaimed gurus in different fields. Add to that the fact that people only post the perfect highlight reel of their lives instead of reality – and we have got a dangerous situation. People look at their feeds on Instagram without filtering or questioning what they are seeing, and that can lead to dangerous results, be it low self-image, political beliefs based on false information, or worse, health problems stemming from following and listening to advice given by non-professionals.

Our team wants to help people minimize the negative effect Instagram has on their lives. We want to teach users to not stop using social media at all, but rather to use it responsibly, think critically and question whether what they are seeing is real and correct, or if it is made in a way to get people to argue between themselves, believe something that didn't actually happen, or buy a product.

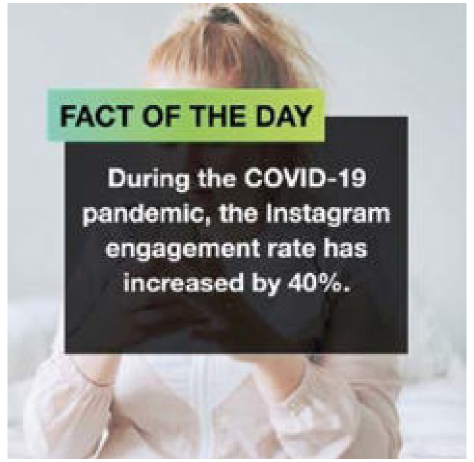
Methods

Our team is working on building an interactive game-like webtool that will teach people how to be aware of the content they consume in a fun way. We will bring facts, games, and little challenges into our tool, and encourage people to do our 7 day detox program where they will hopefully learn that in order to not let social media affect you, you have to be mindful of what you consume.

Of course, a project like this needed an awareness campaign, and since we are mainly focusing on the Instagram feed, in order to reach the people we want to teach, we decided to use Instagram ourselves. To keep it engaging and bring people's attention to the issues surrounding social media usage, we are using the format that is easy to consume – memes, interesting facts, and charts.

Research

As well as teaching people through the program, we want to get some information on how much and in what way it will help them better their relationship with Instagram. We want to know if after our program people have less screen time dedicated to Instagram, as well as if they feel more in control and satisfied with their social media usage. We are planning to answer these questions using self-assessment and questionnaires filled out by people completing the program.



FACT OF THE DAY

During the COVID-19 pandemic, the Instagram engagement rate has increased by 40%.

Impact of COVID-19 on our project

Our project came at a remarkably interesting time in history – we can't meet up and discuss our ideas in person, and everyone relies on social media to combat the feelings of loneliness and boredom. Social media usage has grown – people's awareness of what they are reading or seeing has not. There are as many false claims by non-existent doctors and people about the virus as there are real ones, and it is not always easy to distinguish between them. We feel that our mission is as important as ever. People need to be more aware about the information they consume and believe, especially when it comes to their health.

Team
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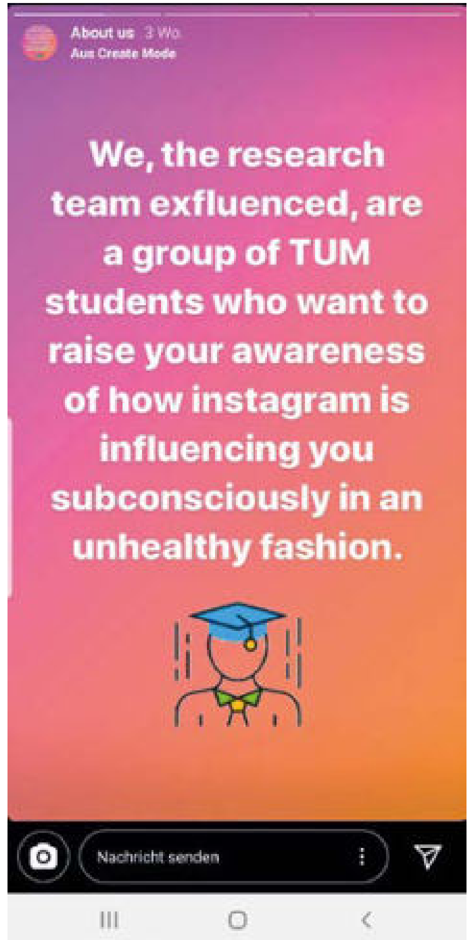
Len Brandes
Andrea Weiller
Maryna Shcherbak
Marie Huemer
Omar Eldeeb
David Noachtar
Laura Ballentin

Tutors
Jakob Scheffels
Christos Gazanis

Supervisors
Prof. Dr. Stephan Jonas
Prof. Dr. Helmut Krcmar



We, the research team exfluenced, are a group of TUM students who want to raise your awareness of how instagram is influencing you subconsciously in an unhealthy fashion.

Exhibition Fish

Introduction

We are Exhibition Fish, a group of students investigating data privacy and the Privacy Paradox in the context of the scholarship program TUM: Junge Akademie of the Technical University of Munich. Our team consists of Franz (MA Responsibility in Science, Engineering and Technology), Joshua (MA Culture and Music Management), Annalena (MSc Health Science), Juan (MSc Mathematics in Science & Engineering), Paul (BSc Informatics) and Renato (MSc Research on Teaching and Learning). Within the call of the TUM: Junge Akademie 2020, "Technology and Arts", we have chosen to focus on data privacy and related behavior among students in Munich.

Why have we chosen to focus on data privacy? Data privacy, in many ways, is an empty phrase that needs to be revived in order to become more tangible and enforceable. Today, data is one of the fundamental building blocks that shapes how people interact, consume, work and experience the world. Our modern society relies more and more on data in order to function well. At the same time, data is often being collected and used in malicious and exploitative ways while individual citizens have little to no influence over these processes.

A seemingly universal answer to these problems is data privacy. However, as a concept, it is neither well defined nor easily accessible to laypeople. Consequently, data privacy is a topic that is difficult to discuss and is therefore not entirely tangible and enforceable in individuals. One seemingly contradictory aspect of data privacy is the privacy paradox, which stipulates that although individuals claim to care about their data privacy, very few people actually take action to protect their data.

In order to further explore the concept of the privacy paradox, one of our project goals is to determine the extent to which the privacy paradox exists among students in Munich. In order to answer this research question, we have sent out a questionnaire assessing data sharing behavior as well as beliefs on data privacy to students in Munich. We hypothesize that we will find evidence of the privacy paradox among students in Munich. Further, we will assess whether informing students that our research topic is the privacy paradox affects how they answer the questionnaire, and to what extent we find evidence of the privacy paradox in this population. We hypothesize that informing students of our research topic will be associated with more cautious data sharing behavior and stronger beliefs on data privacy.

In addition, based on the results from our questionnaire, another goal of ours is to help people to critically question data privacy. We want to identify existing and offer alternative imaginaries through which data privacy is communicated. Here, we hypothesize that identifying and creating imaginaries will help students in Munich to discuss data privacy more easily and will help them to become more aware of their own behavior concerning data privacy and the privacy paradox.

Methods

We will use two instruments to investigate the Privacy Paradox. The first one is the questionnaire that is being applied (from 07.07.2020 to 07.08.2020) to higher education students in Munich. This questionnaire, which was elaborated by Williams and Nurse (2016), investigates if the Privacy Paradox is present in our target population. An online version of this questionnaire, which is hosted on the TypeForm platform, was shared in numerous online pages of groups of students in Munich.

The questionnaire is composed of four sections: (1) required demographics; (2) optional demographics that contains questions with an option "prefer not to say"; (3) opinions, which require participants to rate their agreement with privacy statements and; (4) actions, section in which the participants were questioned about their online privacy actions. We believe this questionnaire will give us a quantitative view of this paradox and also some insights into the elaboration of the second instrument.

The second instrument is a qualitative interview that is still under elaboration. Numerous studies address some theories to explain the reason why this paradox happens. Barth and Jong (2017) affirm in their systematic review that "user's decision-making process as it pertains to the willingness to divulge private information is generally driven by two considerations: (1) risk-benefit evaluation and (2) risk assessment deemed to be none or negligible". Our idea is that the qualitative questionnaire will investigate these considerations but from a different perspective since we believe that these hidden mechanisms in the Privacy Paradox could be enlightened by the artistic approach. Since we want to implement arts in our project in a balanced position with social sciences, not only as a communication tool, we are still discussing the design of the interview and what would be the best approach to reach our goal.

The last phase of our project would be to run an artistic event that proposes people to reflect on how they handle their online data and, thus, having more autonomy about their actions in the online environment.

Team
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Supervisors
Prof. Dr. Peter Gritzmann
Prof. Dr. Maurice Lausberg

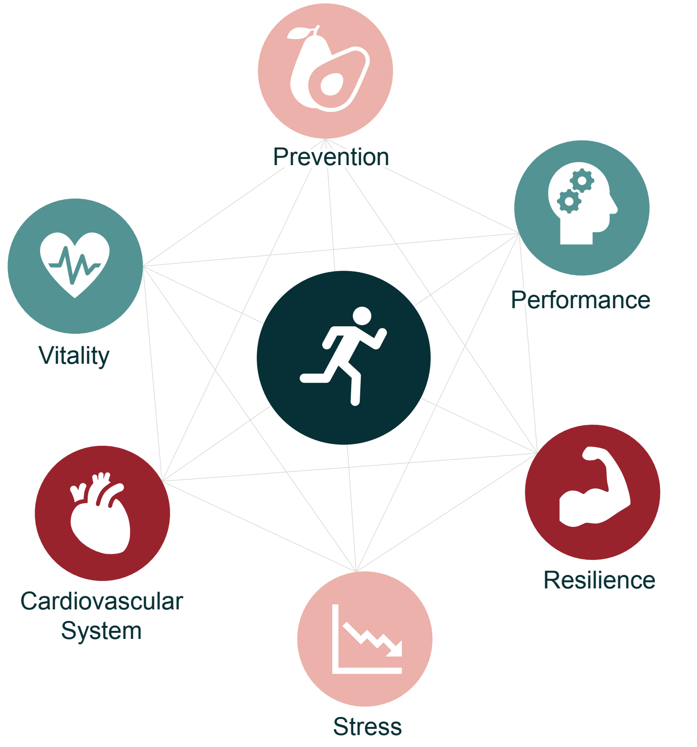
lacktivity

Motivation

Nowadays, an increasing number of people tend to become inactive due to tempting offers that allow to avoid physical activity. Instead of using stairs, the majority prefers using escalators or elevators. Instead of grocery shopping or eating out, people prefer to order food directly to their homes. Instead of going for a walk during the lunch break, people deflect themselves by their mobile phones. And instead of exploring the surroundings by foot or by bike, buses or e-scooters are used.

The growing range of alternatives to physical activity means that the average office worker is no longer sufficiently physically active. In many cases, this leads to unhealthy weight gain. But at the same time, muscle atrophy decreases the holding function of the muscular system, which affects the body posture. Regular physical activity does not only strengthen the cardio-vascular system, prevent certain diseases, and increase resilience, but can also help you deal with stress and clear your mind. On a personal level, a healthy body correlates with increased vitality, while on a public level, our health care system profits from a fit and healthy society as well.

The average office employee does usually not have enough time to take advantage of sports activities in clubs or fitness studios. This person is dependent on having enough physical activity in everyday life. Therefore, we have chosen to dedicate our time at TUM: Junge Akademie to increase every-day physical activity and fight the lack of activity where it is most dominant – among office workers.



Goal & Research Question

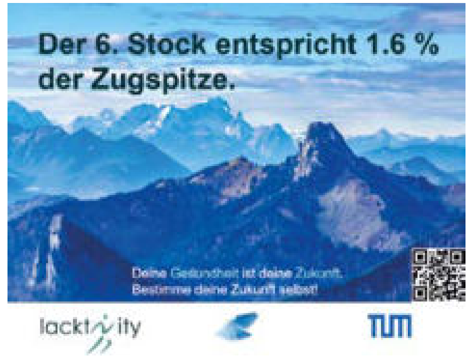
We hypothesize that the amount of daily physical activity can be increased by subconsciously steering people to use stairs during their daily life through different means of communication. More concretely, our goal is to increase the physical activity of employees during their workday “spontaneously” by at least five to ten minutes per day. In order to reach our project goal, we want to evaluate and compare the success of different methods when trying to increase the spontaneous physical activity of office workers. We have therefore defined our research question as follows: Which of the methods (user experience, motivation, deterrence, competition) can most successfully increase the employees’ physical activity spontaneously?

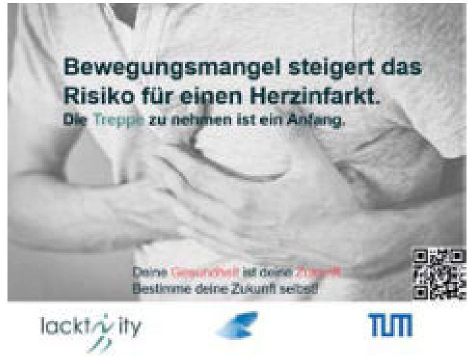
In our research, we are planning to cooperate with a company and evaluate the success of each method. In our research, we are planning to cooperate with different companies and evaluate the success of each method.

Implementation

In order to promote increased physical activity, different methods like interactive user experiences, posters for motivational or deterring purposes (see pictures) and competitions with different rewards will be tested. They all share the intention to subconsciously steer people to use stairs more often. Currently, we are planning to implement four methods as specified in the attached table. The impact of each method on the spontaneous physical activity of the employees will then be assessed scientifically in order to provide a thorough comparison of the chosen methods. Our project requires the presence of employees in their offices. Consequently, the implementation of our project might be delayed due to the current Covid-19 situation. Project planning, including elaboration of methods and contacting companies, however, is not compromised, which is why we pursue our original project plan. ■

	Use Caise: Walk
User Experience	QZ codes with fun facts in the middle of a staircase
Motivation	Motivating posters at junction between stairs and elevator
Deterrence	Deterrent posters at junction between stairs and elevator
Competition	QU code based token system for competition between departments with rewards such as canteen seats or vouchers


Der 6. Stock entspricht 1.6 % der Zugspitze.
Deine Gesundheit ist deine Zukunft.
Bestimme deine Zukunft selbst!
lacktivity
TUM

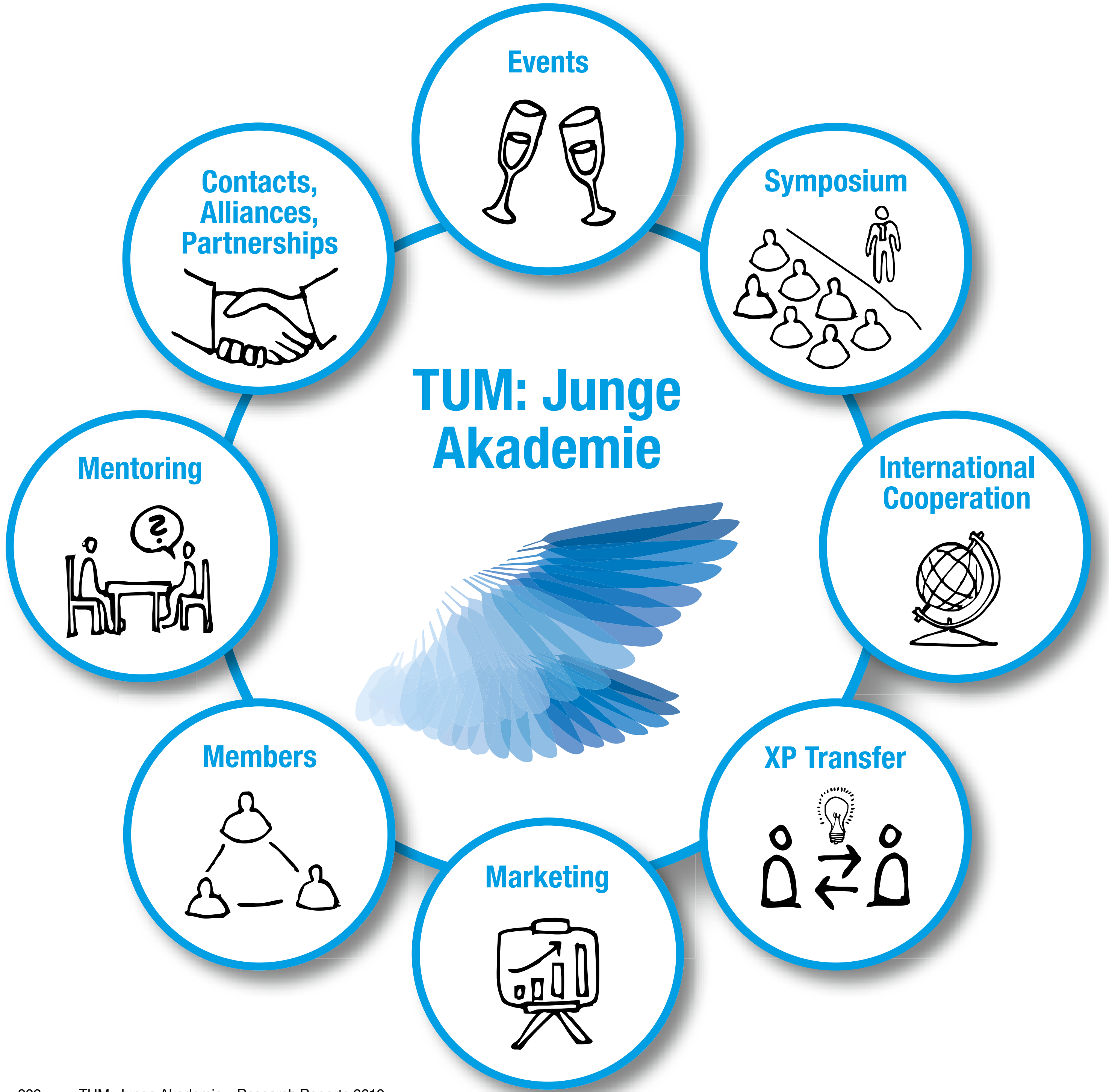

Bewegungsmangel steigert das Risiko für einen Herzinfarkt.
Die Treppe zu nehmen ist ein Anfang.
Deine Gesundheit ist deine Zukunft.
Bestimme deine Zukunft selbst!
lacktivity
TUM

Team	
Maren Bertling	Laura Hoffman
Matthias Brucker	Florian Hübler
Monica Déchène	Joel Jäschke
Christian Faßbender	Benedikt Vollmann

Tutors	Supervisors
Veronika A. Bauer	Prof. Dr. Bertold Hock
Thomas Just	Prof. Dr. Volker Nürnberg

Taskforces

Taskforce CAP ... 223
Taskforce Event ... 224
Taskforce International ... 225
Taskforce Marketing ... 226
Taskforce Members ... 228
Taskforce Mentoring ... 229
Taskforce Symposium ... 230
Taskforce XP transfer ... 231



Taskforce CAP

CAP stands for "contacts, alliances, partnerships" and represents to a certain extent what taskforce CAP does. In general terms, we have two main goals:

1. Provide funding for activities of the TUM: Junge Akademie which are not covered by the budget provided by TUM.
2. Establish and maintain a network between scholarship holders, alumni and companies through partnerships.

Provide funding for activities of the TUM: Junge Akademie not covered by the budget provided by TUM. TUM provides funding for the TUM: Junge Akademie as a scholarship program. This funding is intended for the academic benefit of the scholarship holders, e.g. by enabling workshops or supporting the students' projects. However, those financial means cannot be used for things like food or accommodation. As the TUM: Junge Akademie has on average two weekend seminars per semester, which take place in locations around Munich, scholarship holders would have to spend money to attend them. To avoid this and to enable every student to participate in the Junge Akademie regardless of their financial situation, we as taskforce CAP seek additional funding to cover these expenses. This is done by finding external partner companies and organizing events like the Science Hack, which will be introduced below.

Establish and maintain a network between scholarship holders, alumni and companies through partnerships. The TUM: Junge Akademie understands itself as more than a 20-month scholarship program, but as a network of talented and dedicated people who want to actively contribute to the development of our society. Therefore, it is important to have not only scholarship holders, alumni and professors involved in the Junge Akademie, but also to establish and maintain partnerships with companies. All parties involved in this interconnected network benefit from the exchange of ideas and the development of cooperation. Since 2016, the TUM: Junge Akademie is happy to have had Pixida as a precious and lasting partnership. Besides keeping close contact, Pixida also sets up workshops for the scholarship holders and helps with their projects wherever possible. We as taskforce CAP take care of our partnership with Pixida and aim to establish cooperation with new partners.

Science Hack. Last December, taskforce CAP organized the second Science Hack, which was a great success. The Science Hack is a hackathon hosted by the TUM: Junge Akademie in which both companies and chairs of the TUM provide tasks for the participating students. Due to the variety of the offered tasks, not only people who study computer science but a more diverse cohort of students can participate. The goal of the Science Hack is to use the already established contacts of TUM: Junge Akademie with companies as well as within the TUM to provide a unique event for all students in Munich. Besides, we hope to arouse interest among new companies in the TUM: Junge Akademie and the opportunities associated with sponsoring the Science Hack or establishing a permanent partnership. Originally, the third Science Hack with the slogan "*Utopia – future cities worth living in*" should have taken place at the main campus of TUM on June 27th – 28th 2020. Due to the exceptional situation, which has occurred due to the Sars-CoV-2 virus, both the taskforce CAP and the management of the Junge Akademie decided to postpone the event. Currently, we are still in the planning process to find a new, suitable date and are in contact with different companies to establish collaborations for the Science Hack.

Members of CAP. The current CAP team consists of seven students from the TUM: Junge Akademie Year 2019 and seven new members of Year 2020 who joined the taskforce in February 2020. The new members will be the main organizers of the Science Hack 2020.

Julia Angerer
Matthias Brucker
Omar Eldeeb
Daniel Frey
Simon Gandorfer
Franz Xaver Gillmeyer
Madeleine Hotter
Xingyi Huang
Friederike Jungmann
Matthias BruckerSarah Kluge
Bruno Villela Pedras Lago
Kilian Lupp
Nitish Nagesh
Juan Esteban Suarez ■

Taskforce Event

Who we are and what are we doing?
The Taskforce Event of the TUM: Junge Akademie is an independent working group which was founded in the academy's early years. Your experience in the Junge Akademie does not only revolve around working on projects, but also learning new things, having fun, and enjoying your university life. Our goal is simple: we want to broaden your horizons and establish connections between current and previous scholarship holders. The scholarship holders come from all sorts of disciplines and have different cultural backgrounds from all over the world. No matter if you are a new member or have already finished the project work and have a job now – once joining the community, you are always welcome to join our events.

How does it work?
In the Taskforce Event, you decide what types of events you want to organize and then realize your ideas! We have visited museums together, watched performances in the opera house, gone hiking on weekends, and cooked together. We also organize events such Stammtische, game nights, Christmas parties and even group workout sessions. With your ideas and contribution, everything is possible here. And most importantly, you also get support from the academy.

What events, for example?

■ **Running Dinner**
At the Running Dinner, you have a three-course menu at three different places. You and your teammate are responsible for preparing one of the three courses, while being a guest for the other two. Therefore, during the event, you will get to know other people. To round off the evening, all participants meet in a bar after the dessert.

■ **TUMJA goes Brewery**
In January 2020, we went to visit the brewery Spatenbräu and all members and alumni were welcome to join! We had a two-hour-long guided tour there to get insight into the brewery and its processes.

■ **Exclusive guided tour through the BAYERN 3 radio studios**
Ulli Wenger is a legend in the Bavarian radio scene. Exclusively for TUM: Junge Akademie scholarship holders, he opened the doors so that we could take a look behind the scenes of the traditional BR building and BAYERN 3 radio studios. On top of that, we got the chance to talk to Dr. Jeanne Rubner, the head of science communication and educational policy.

■ **Private visit to the ESO Supernova**
The ESO Supernova Planetarium & Visitor Centre is a cutting-edge astronomy center free to the public located near the ESO Headquarters in Garching. We had a great planetarium show and a private building tour to explore the secrets of the architecture.

■ **Christmas party**
Music, friends, pizza, Christmas snacks, beer – in summary: Fun!

What are you waiting for? Come and join our events!

Year 2019:
Sophia Hasbach
Ho Huang
Samuel Valenzuela

Year 2020:
Magdalena Bader
Silvia Bergt
Milan Cupac
Christopher Ebert
Maximilian Passek

Taskforce International

In times of right-wing populism and increasing isolation of countries, international organizations like the European Union fear inconsistency and decreasing acceptance. It is more important than ever to build transnational connections and look out for partners who are like-minded. This taskforce feels the urge to bring a greater international perspective to the TUM: Junge Akademie in order to exchange ideas, to create connections and to engage in mutual discourse.

Who we are:
We are students from different fields of study who are fully motivated to build up networks with other international universities which have similar projects to the TUM: Junge Akademie.

Our goal:
We want to create an intercultural exchange amongst students from international universities involved in similar projects as the TUM: Junge Akademie. During this exchange, we will give an interdisciplinary scientific insight into the work of the different TUM Campuses. The students will explore the fields of research at TUM through a variety of organized workshops, guided tours and playful challenges. Needless to say, there will be a leisure program, trips to cultural events and places of interest and tradition. Through the workshops we want to foster relationships and networks with our international partner universities.

The program:
The duration of the program will be five days with a number of ten participants from each university. It is similar to the concept of a summer school. The workshops are going to take place in groups and there will be at least one big tour around Munich. The students should have the possibility to propose ideas for events, tasks and improvement. We support a one-to-one-pairing during the exchange, so the TUM-partner can help to look for accommodation, bring the German language closer to the visitor and give insights into the German culture. Furthermore, the taskforce members will work on planning and implementation. For the first exchange in summer 2021 the topic "cities of the future" were chosen. The students will investigate approaches for architecture of modern buildings or environmentally friendly mobility in different interdisciplinary tasks.

Current project:
Our latest project is to build up a partnership with Imperial College London (ICL). In fact, Imperial College London is ranked as one of the top ten universities in the world and offers several scholarships which fit in with our profile. A delegation of our taskforce travelled in November 2019 to the ICL and had discussions with the leader of the iExplore program, a potential and promising partner program. The start of the exchange with ICL is planned for September 2021. Furthermore, we have begun discussions with the Technion in Haifa, Israel. The Technion belongs to the network of the Euro-Tech Universities. The first contact was very positive, and we will further expand our partnership in future.

History:
In April 2019, a delegation of Imperial College London visited the TUM Campus in Garching. Three members of the taskforce International attended the meeting. We did a guided tour through the entrepreneurship center of TUM and the Makerspace. In a presentation, we explained our goals and the program. To foster the relationships, build a network, and improve our work, Prof. Buitendijk, the vice provost for education, invited us to the college in London. With this visit, we hope to find other students who want to build up a common project so our exchange can start as soon as possible. Our delegation traveled from 3rd to 5th of November 2019 to the ICL and had conversations with several interested partners. Among these were:

- Dr. Caroline Clewley: leader of the iExplore program
- Mr. Ashley Brooks: deputy president of the student union
- Mr. Mark Streule: Director of student shapers program

Year 2019
Karlis Blums
Alexander Karollus
Jan Kochanowski
Johaina Kullab
Dominik Schindler
Tobias Spöttl
Stephanie Stockert
Maximilian Wagner

Year 2020
Ario Dastmaltschi
Maryna Shcherbak
Jan Luca Scheerer
Paul Andrei Sava
Mohamed Shoeir
Nina Zuber

Taskforce Marketing

As the task force Marketing, we are mainly responsible for raising the public profile of the TUM: Junge Akademie through strategic campaigns. This requires us to be in close contact with the main office and other task forces to coordinate our activities. Our ongoing projects include representation at the IKOM and the "Tag der Initiativen" in Garching.

Simultaneously, we create marketing strategies for TUMJA events like the annual Science Hack or the Symposium to raise publicity. Due to the campus closures in the wake of the COVID-19 crisis, we shifted our main focus to digital advertising, mainly through social media. We plan to incorporate these ideas into the marketing campaign for the upcoming application process to reach as many students as possible.

For this, our aim is to create a short film in collaboration with task force Event to reflect the essence of this scholarship not only to aspiring applicants but also to the general public. Additionally, we are currently developing new concepts to appeal to these target audiences.

Our work also includes the design of TUMJA merchandise: The creation of our 10 year jubilee logo is just the first step of what is to come. We are already looking into options for TUMJA exclusive items after the success of this year's hoodie.

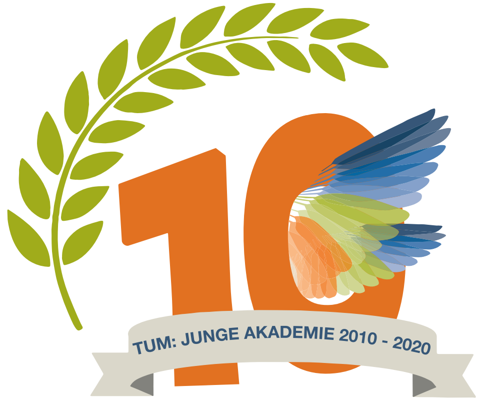
In addition to this, our task force offers help to the group projects of the TUM: Junge Akademie to master the challenge of promoting their work. Hence, this support and commitment is our central responsibility in relation to the interdisciplinary scholarship program.

Regarding the upcoming ten-year jubilee, we are planning to produce an image video to celebrate this history by interviewing alumni, professors and active scholarship holders. In the future, we hope to expand our corporate identity to generate a framework to establish the TUM: Junge Akademie as a prime option for high-achieving students in Munich.

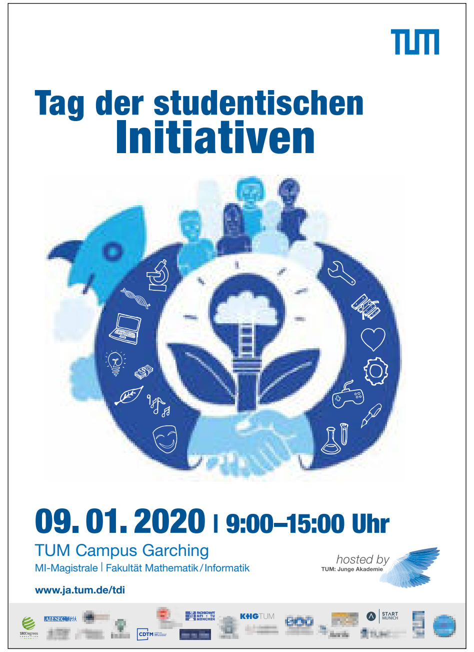
Our members come from various fields of study – often without a background in marketing. However, this does not impact our performance: Together as a team, we come up with creative ideas for promoting the TUM: Junge Akademie. Creating new and exciting solutions is essential to our task.

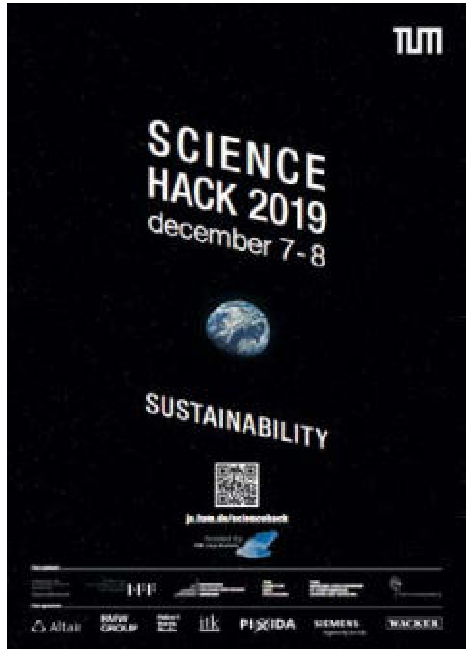
This includes a high degree of creative freedom for our projects. Therefore, we offer a lot of hands-on experience in the various aspects of marketing to our members. Students aspiring to join the task force Marketing will thrive by facing these challenges with enthusiasm and creativity.

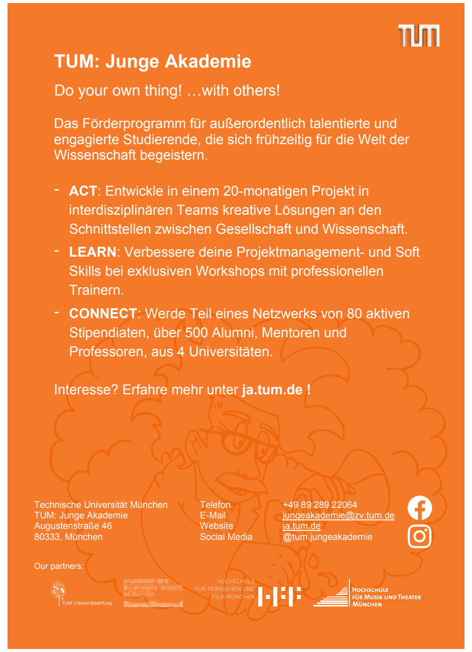
The following poster and pictures showcase some of our work during the last year:
- Poster for the "Tag der Initiativen" in Garching at the beginning of 2020
- Poster for the "Science Hack" at the end of 2019
- Photo from January's seminar weekend with almost all active scholarship holders wearing the TUMJA hoodie
- Poster for the "IKOM" event (planned for mid 2020, cancelled due to the Corona pandemic)
- TUMJA 10 year jubilee logo



Laura Ballentin
Altan Birler
En-Hsin Chung
Niklas Dreymann
Joshua Sharon Neumann
David Noachtar
Patrick Sowinski
Elena Tangocci
Benedikt Vollmann ■







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Hochschule für Musik und Theater München

Taskforce Members

We, the taskforce ”Members,“ are responsible for all issues concerning the active members of the TUM: Junge Akademie, our Alumni and members-to-be. Therefore, we act as a link between the office and our members.

Annually, we plan and organize the application process. Therefore, we organize several information events in order to provide insights into the TUM: Junge Akademie for interested students. Students are given the opportunity to meet active members and gain first hand insights into the TUM: Junge Akademie. Due to the Corona situation, we held three online information events via Zoom. Our goal is to popularize the scholarship program and to attract more potential members. Therefore, in 2020, not only the best two or three percent of TUM students, but the best ten to fifteen percent were nominated.

We are furthermore responsible for organizing the selection days. During two days, applicants are asked to participate at various tasks, for instance presenting their project idea to other students and having an interview with a supervisor. Based on their performance, about sixty to eighty students are then chosen to participate at the TUM: Junge Akademie. Last year, we completely restructured the selection days. These now include a group activity. We also introduced a score for assessing the applicants’ performances. This score facilitates the comparison of the applicants and helps assuring that the selection process is fair and replicable. This year, we are going to examine the scoring system and further improve it. We are also going to work on a concept for conducting online selection days in case the situation with corona becomes worse.

In addition, we conduct and analyze several evaluations, for instance regarding seminar weekends, in order to improve the scholarship program and to ensure the well-being of our active members. This enables us to tackle any occurring challenges immediately, raise awareness and propose improvements. At the same time, it is our role to try to guarantee that the program is to the entire satisfaction of everybody, active members, supervisors and tutors.

We warmly invite you to give feedback, to make further suggestions or to ask questions. Do not hesitate to contact us via members@jungeakademie.tum.de or to talk to us directly.

Veronika Bauer
Maren Bertling
Monica Déchène
Stefan Engels
Laura Hoffmann
Annalena Huber
Dennis Huber
Marie-Theres Huemer
Lea John
Stefan Lehner
Beate Neu
Jonas Papazoglou-Hennig
Judith Paripovic
Pascal Resch
Sophie Schwarz
Katharina Johanna Wagner ■

Taskforce Mentoring

The taskforce "Mentoring" designs a mentoring program for current scholars of the TUM: Junge Akademie. We strongly believe that mentoring offers great benefits for both parties and is a valuable part of the curriculum of the TUM: Junge Akademie. Our program provides a means of initiating one-on-one contact between scholars and alumni of the TUM: Junge Akademie. Thus, individual advice and inspiration can be passed on from experienced alumni to younger scholars. At the same time, mentors get a chance to keep in vivid contact with their Alma mater and can benefit from the next generation's knowledge and enthusiasm.

We are proud that we have more than doubled the number of participants from six to thirteen tandems in the second year. Thirteen scholarship holders signed up and reviewed a list of possible mentors including their study background, LinkedIn or XING profile and other personal information. We thought that it might be best to let the mentees choose their mentors on their own as they know best whom they would like to exchange with. Hence, they ranked the mentors in their preferred order and the matching tool computed all the rest. In May 2020 we organized a virtual kickoff event on ZOOM to introduce tandem partners to each other, explain the process of the mentoring program and, most importantly, to spend a fantastic evening together by playing a variety of games.

In general, tandems can organise their interaction very individually: While mentor and mentee should meet at least four times during one year, the frequency as well as location and topics discussed are set individually. Academic questions as well as personal topics are encouraged to be discussed. At the end of the program, there will be a closing event, which is the kickoff event for the next year of mentor/mentee tandems.

We are looking forward to performing the next steps. Stay tuned!

Your Mentoring Taskforce

Renato Coppi
Christian Faßbender
Florian Hübler
Joel Jäschke
Aikaterini Mavroudi
Marius Merkle
Jessica Neußer
Youssef Walha
Andrea S. Weiller ■

Taskforce Symposium

Why do we have a TF Symposium

Our taskforce is part of the TUM: Junge Akademie and was founded in summer 2019. The main task is to organize the yearly symposium. The symposium is the final event of each year with interesting presentations about the year's call. At the kick-off for organizing their symposium, the year 2019 listened to the organizers of the 2017-2 symposium and how much effort it required. Unlike other taskforces, this taskforce was first established during the present year. Therefore, at the beginning, it comprised only members who had left their former taskforces to join.

What has the TF Symposium done so far

The call for Year 2019 was "multimodal science communication." Thus, we wanted to build a bridge between this topic and those going to be discussed at the Symposium 2020. Among others, we decided to present the topics in the format of a science slam. Each team should select one representative to present their content in the format of this slam. After every team nominated one slammer, a workshop with professional science slam trainers was organized in May. Due to the outbreak of the Coronavirus, unfortunately the workshop as well as the symposium in June had to be cancelled.

How does the time of a member in the taskforce look like

The taskforce Symposium aims to encourage cooperation between new and old members to interlock like cog wheels. When the new batch of scholarship holders start working in the taskforce in February, the previous batch will have already prepared their concept for the symposium. So during the first months, one will be able to learn how to organize a symposium from the members of the previous batch. Now it is our time and chance to create the concept for this year. While we are given full creative freedom to develop a concept and plan the symposium, we are also supported and guided by the other members of the TUM: Junge Akademie.

Saskia Hutschenreiter
Jaimee Lau
Rebecca Marichalar Quezada
Paul Sieber ■

Taskforce XP transfer

Imagine being a time traveler and you travel back to the ancient Roman Empire. Despite being so long ago, you might be impressed by their many achievements, like well-organized and quite clean cities with sewerage systems, or such seemingly simple things like baking nice bread. Now, let's travel forward in time by some centuries – we end up in the European Middle Ages. We look forward to all the progress mankind made within these centuries, but what is this? People pour their drain water just directly onto the streets – and, in any case, do these ways deserve the name "street" at all? And also the bread is not really tasty.

What has happened? The Roman Empire dissolved, and with it a lot of know-how and experiences just disappeared.

Transfer within TUMJA

Let's travel back to the present age and take a look at the TUM: Junge Akademie. A group from the current year struggles to create a well-made survey and wonders how to recruit enough participants. Of course, the group members are smart and search the Project Book of former years, where they see several examples of conducted surveys. They even find some people of those groups being still active within the Junge Akademie. But … it is already some time ago and these people don't remember the details.

Another group has just started to establish contact with partners and wants to use their group's shared mailbox. The TUM: Junge Akademie office has sent them a two-page long instruction and the specific "CN-Funktionsobjekt" they have to use. Nevertheless, they fail a couple of times to include this mailbox in their mail clients. Until one of them figures it out and explains to the others how this works – on half a page.

Time traveler smiles a bit – the situation has not changed a lot over the course of history: People still acquire a lot of know-how and experience in their time, but later this is then lost to some extent.

Wouldn't it be great to open the TUM: Junge Akademie experience pool and get this half-page tutorial on how to make the shared mailbox work? And even more awesome to find another short article about the main lessons-learned by the former groups that created a survey?

Intro and purpose of Wiki

The recently founded Taskforce Experience Transfer (XP Transfer) is targeting exactly this issue.

We want to establish a platform to serve as a starting-point for people to search for solutions which can help make their tasks easier and more effective within their project groups and taskforces.

As a platform we want to use the TUM-wiki, a wiki system based on Confluence. The wiki is an online platform, where each member of the TUM: Junge Akademie can log-in and create new, or edit existing, pages within a tree-like structure. Working with a single page in the wiki is quite easy because the page editor works in a “what you see is what you get” way.

Today, already many groups and taskforces work with the wiki to some extent: A lot of agendas and protocols can be found, several pages where people have discussed how to proceed. Many other pages where know-how is written down also exist in the wiki – but they are often very difficult to find for users who are searching for a solution.

Plans from the TF

It is exactly at this point that the Taskforce XP Transfer comes into play. We want to create a sustainable structure within the wiki to have a framework for transferring know-how and experiences.

The very first issue to tackle is to create a clear tree-like structure where people know directly where to search for solutions. This can be, at the top level, a division into the project phase, taskforces, tutor experience, TUM: Junge Akademie office and IT. Within each branch we want to introduce clear sub-divisions to further refine the model. This should prevent confusion by by too many pages being saved at one point because people did not know where to save a new page properly.

As a second step we want to create easy-to-use templates and guidelines for creating a page. This will make pages more comparable and will also lower the threshold for creating a new page. For example, it is often more helpful to have a brief summary of all the relevant points in a bullet point form, than having a long running text over many pages; compare this to the above mentioned set-up of shared mailboxes.

The third main point is to write the first pages. These can be pages about any topic of relevance in the TUM: Junge Akademie. These should serve as examples for other people to write new pages – and of course the pages should already be useful in general for others. A particular focus of the first articles will be the wiki itself; despite many TUM: Junge Akademie members already working with the wiki, the majority use it for only a limited number of different things. E.g. a lot of users might not know how to create a new page from a template.

We focus on these initial problems at first, because it is extremely important to introduce new tools and ideas properly and to communicate the opportunities and challenges well. Otherwise people will experience frustration at a very early stage and will blame the system, here the wiki, for being a poor system.

To highlight the importance of this, let’s take a quick excursus to the Munich town hall. They shifted their IT infrastructure from Microsoft Windows based to Linux based. For IT-informed people this was no big deal, as Thunderbird is very similar to Outlook, LibreOffice Writer similar to Word, and so on. However, for the common user of these programs there was a difference and trying to adapt their existing knowledge was not always sufficient, because things had different names or were located in a different place within the programs. These should not be severe problems in themselves, but without proper introduction hundreds of people had to search for the same things and all became frustrated. This is of course a simplification, but in the end the general frustration was so high, that Munich had to shift back to Microsoft Windows – again incurring costs for changing a main ingredient of their IT infrastructure.

Coming back to the Taskforce XP transfer. After the general structure is established and first pages are created, we want to properly introduce the wiki and the newly created opportunities for all the other taskforces and groups. At a very early stage, they should experience the benefits of a wiki filled with helpful experiences, and in turn be motivated to share their experiences with the community of the TUM: Junge Akademie.

Outro

Our time traveler is curious how it worked out and travels a bit forward in time. He is quite happy to see that the TF XP Transfer no longer exists because each member of the TUM: Junge Akademie searches first at the wiki in case of problems and then updates the page after their group has performed the task – or they even create a new page to save the experiences for the next generation. Thus, making the Taskforce superfluous.

The time traveler realizes that this wiki-based solution works in this case. Taking a look in a history book he notices that the ancient Romans also had a kind of wiki to save know-how – called “libraries”!

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Our industrial partner

Our industrial partner 236

Pixida Group

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Cooperation TUM: Junge Akademie

Since 2016 Pixida GmbH is a cooperation partner of „TUM: Junge Akademie". Together with passionate students, our experts in digitalization, Internet of Things (IoT) and mobility exchange knowledge on potential solutions for urban and public challenges.

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 participates in Science Hacks organized by TUM: Junge Akademie.

In 2019 Pixida hosted the workshop "Smart Cities and Digitalization" for enthusiastic students. Urbanization has a major impact on society and in the environment. The changes in urban areas cause new challenges and require innovative solutions. The workshop was focused on IoT applications within Smart Cities, an exemplary approach to measure air quality and an evaluation of blockchain cryptography.

The students visualized and discussed several IoT solutions and improvements through Data Analytics dealing with questions such as "Smart Cities and IoT – what does it mean?" or "How to use IoT and the cloud to make a city smarter." The final topic focused on "Blockchain – a broken chain of trust".

At the second edition of TUM Science Hack in December 2019 two student teams worked on the PIXIDA challenge how to promote eco-friendly driving. Both teams developed Web-Apps to visualize the eco-friendliness of trips. By enriching the provided dataset with free accessible online content individual statistical modelling approaches were applied for eco-score calculation. The result was really impressive: beside of live map visualizations, trip details, individual recommendations how to improve eco-score also gamification approaches were considered in order to share and compare the driving style within the online community.

Both student teams used the opportunity to present their results to Pixida's Managing Directors and Leading Experts in a follow-up meeting. Further background knowledge as well as current development trends were discussed in a unique and interdisciplinary setting.

Since August 2020 Pixida supports two project teams of TUM: Junge Akademie in terms of app development. The aim of team EnterTrainment is to raise consciousness about transportation habits, awareness about their impact on the environment and promote eco-friendly behavior among young adult population. The second team, AppCycle, is especially motivated to find a creative way building a platform to inform and contribute to Munich's environment, concentrating on the re- and upcycling situation in the city. The Pixida team will provide general impulses and concept reviews in the fields of functional development, architecture, data security and design.

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!

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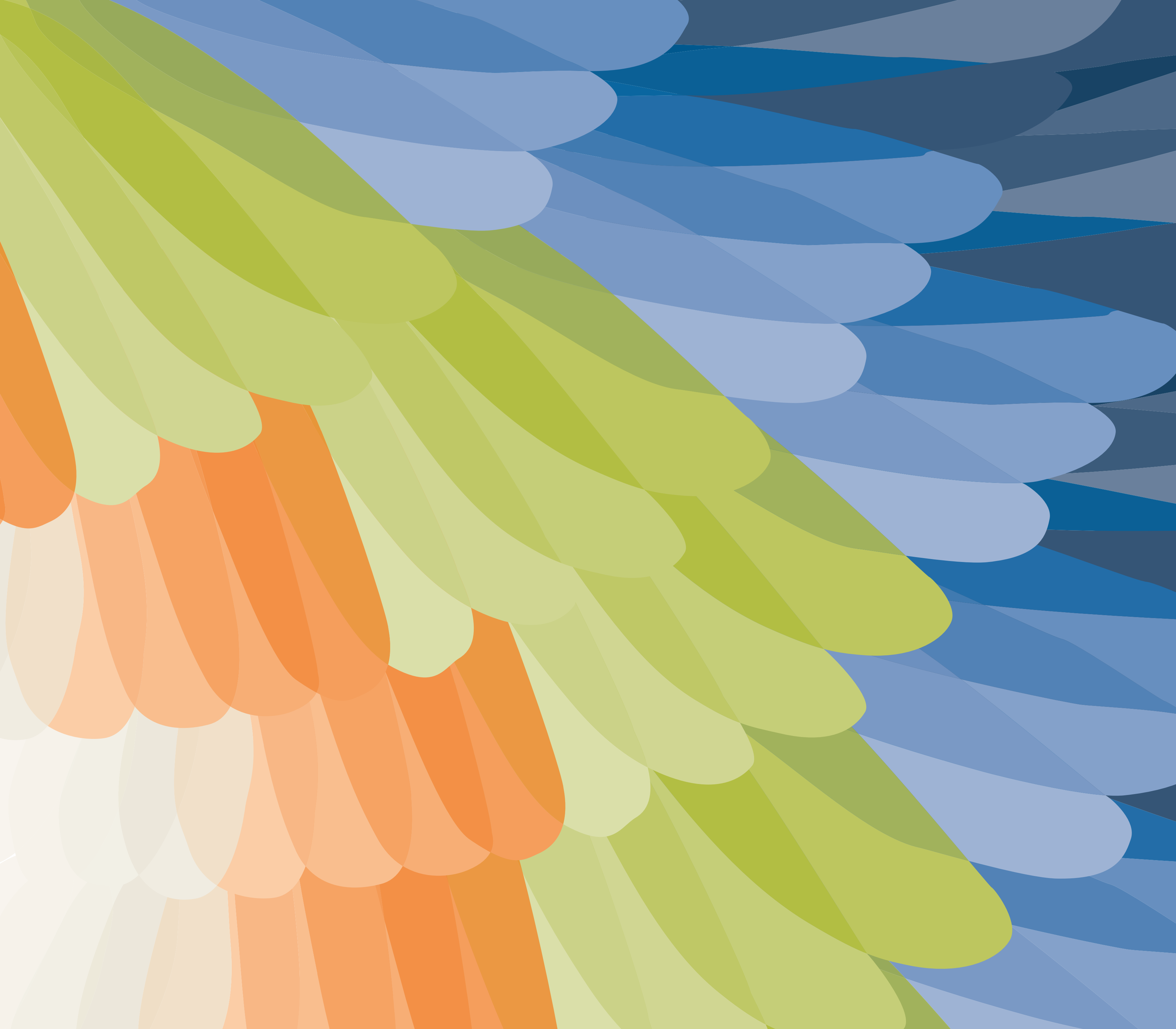Number of copies 1000