



# Project Report **StudyStrats**

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## 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 Akademie 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. ■

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**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, Extra-



version, 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 (Mean = 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).

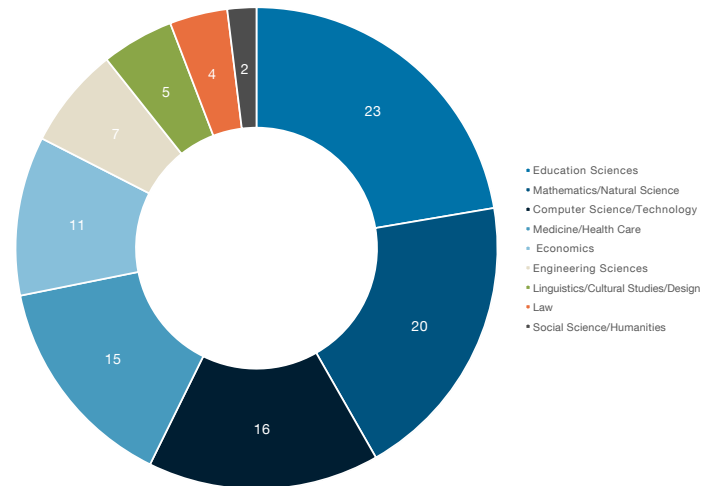


Fig. 1: Subjects by professional background (N = 102)

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.

LEARNING STYLES AND LEARNING TOPIC MATRIX			
	TEST PERSON A	TEST PERSON B	TEST PERSON C
TOPIC VISUAL SYSTEM			
TOPIC BREWING			
TOPIC LIVING IN SPACE			

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 per-

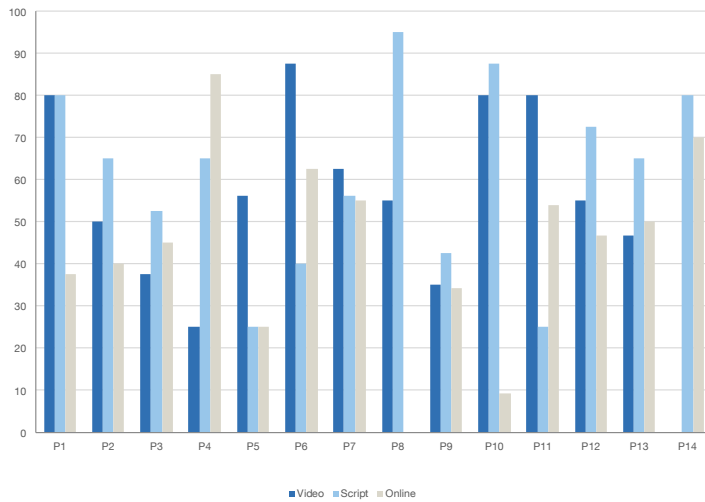


Fig. 4: Scores in percentage of the three learning strategies of each participant

fect 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.

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 ( $M = 40.2$ ;  $SD = 2.39$ ).

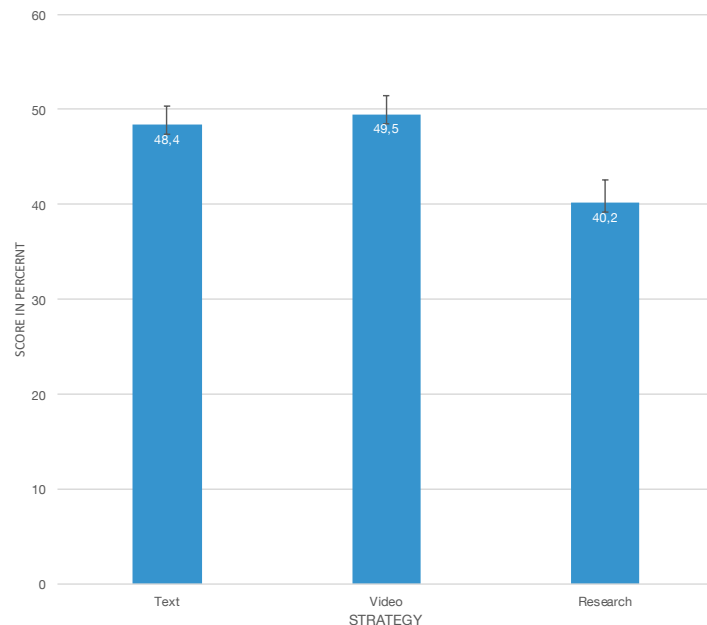


Fig. 5: Statistics of the three learning modalities

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 covariates 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

Cases	Sum of Squares	df	Mean Square	F	p	$\eta^2_p$
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

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).

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. ■

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## 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 conduct, 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 lived 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 dif-



ferences. 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! ■

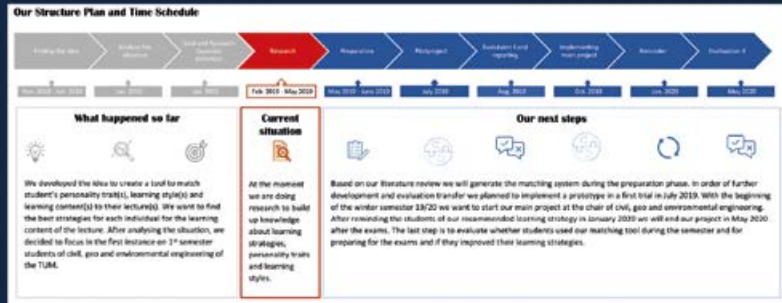
# study strats

## 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 1<sup>st</sup> semester students' of civil engineering.



## HYPOTHESIS

The matching system enhances students' learning performance.



- MEMBERS** Lea John, Friederike Jungmann, Kilian Lupp, Elena Denise Tangocci, Samuel Valenzuela, Katharina Johanna Wagner  
**TUTORS** Konrad Weiß, Martin Zimigbi  
**MENTOR** Prof. Dr. Azzurra Ruggeri



MAY 2019

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.

TUM

# 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.



**LEARNING LOOP**  
 PASSIVE LECTURE ACTIVE ONLINE SEARCH

**QUESTIONSTRATS PILOT**  
 1. QUESTIONNAIRE  
 2. ACTIVE & PASSIVE TEST  
 3. BLOCK LEARNING

**QUESTIONSTRATEGIES PILOT**  
 3.1 BLOCK LEARNING

	TEST	TEST	TEST
	QUESTIONNAIRE	QUESTIONNAIRE	QUESTIONNAIRE
TOPIC VISUAL SYSTEM	📄	📄	📄
TOPIC BREWING	📄	📄	📄
TOPIC LIVING IN SPACE	📄	📄	📄

## 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.

## 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.*

## 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 Tangood, Samuel Valenzuela, Katharina Johanna Wagner

**TUTORS** Konrad Weiß, Martin Zirnigibl

**MENTOR** Prof. Dr. Azzurra Ruggieri

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. ■

# study strats

## 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

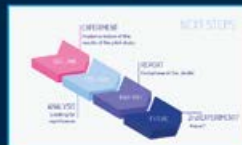
So far, we developed a questionnaire and knowledge tests to analyse student's learning preferences and personality. To test what we created, we run a pilot study, in which participants answered our questionnaire and studied three topics (visual system, brewery process, and life in space) with each a 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

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### TUTORS

Konrad Weiß, Martin Zingl

### SUPERVISOR


Prof. Dr. Azzurra Ruggieri




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. ■







**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 style 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

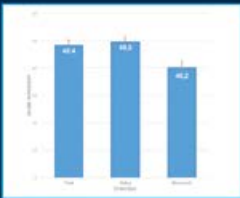
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**SUPERVISOR**  
Prof. Dr. Azzurra Ruggeri


**STATISTICS OF THE THREE LEARNING MODALITIES**



Source	Sum of Squares	df	Mean Square	F	Pr > F
Topic	11.999 000	2.000	5.999 500	10.217	0.001
Learning modality	411.000	2.000	205.500	3750	0.000
L1 Content	32.250	2.000	16.125	0.279	0.606
L1 Pace	4.500	2.000	2.250	0.039	0.960
Topic * Learning modality	1.052 000	4.000	0.263 000	0.466	0.917
Topic * Content	68.250	4.000	17.062 500	0.307	0.956
Learning modality * Content	108.120	4.000	27.030 000	0.483	0.939
Learning modality * Pace	85.120	4.000	21.280 000	0.379	0.959
The interaction					



SEPTEMBER 2020



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. ■