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High-school students engaging with researchers within a pre-university programme: Motivations and experiences

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Abstract

For students, the transition between secondary school and higher education can be problematic. Their prior knowledge may be insufficient, they may lack the right attitude or not have enough skills for university. Especially gifted students often lack challenges to remain motivated. Moreover, it is not easy for secondary school students to get a good picture of a variety of further studies. For their teachers, it is difficult to keep students informed about actual research in science and technology, as they are not in touch with this research on a regular basis. In this paper, we report about experiences of more than ten years at Utrecht University, offering pre-university students opportunities to be involved in lectures, workshops, laboratories and research at the university. We report on students' motivation to register for this programme, and their experiences afterwards. Important categories of motivation and experience are: raising interest in science; the choice of, and preparation for, further studies; working with a group of similar, motivated students; the wish to be challenged; and the experience of doing research at the university. University lecturers involved in the programme like to work with these students, and are motivated to share their research experiences.

Keywords: transition school and university; science and mathematics education; talent development; motivation

Key messages

- It is possible to run a successful programme for talented students by engaging them in a large number of university experiences (including research) during their last two years in secondary school.
- Such a programme requires close cooperation between universities and secondary schools, including long-term commitment and financial investments from all institutions involved.
- Students' main motivations for participating in such a programme are the interesting and instructive characteristics of the programme, its challenging nature and the orientation it offers on future studies and careers. Researchers' main motivations are their own pleasure in teaching these students and the promotion of scientific research.

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Introduction

During their school career, most students will attend a series of different types of school. From kindergarten, they go to primary school, then secondary school, and finally they go to university or college, before entering the job market. In this paper, we focus on the transition from secondary school to university. Although school transitions are necessary in view of the kind of education offered (for example, more specialization, other pedagogical circumstances), each transition from one school to the next involves some issues concerning the continuous learning progression of the student. How well prepared are students for the new institution? Do they have the right prior knowledge to follow the courses and, perhaps even more importantly, the correct attitude and skills? And, from another perspective, does the new school or university fit its programmes to the entering students? Clark and Lovric (2009) define a transition to be successful when the student is comfortable in her/his new role as university student, is able to achieve and work towards her/his goals, shows good academic progress, has support (both academic and otherwise) and can access it when needed, and enjoys the new courses. Rach and Heinze (2017) show that specific precursory knowledge related to scientific mathematics, and students' abilities to develop adequate learning strategies are the main factors for a successful transition phase. Another issue in the transition from secondary to tertiary education is whether students make the right choices: does the new institution or programme correspond to the perception of the student upon entering? And – especially for universities and colleges – does the spectrum of job possibilities upon graduation fit with the needs and wishes of the student? Dealing with these transition issues is the responsibility of both the discharging and the receiving institution.

Within each school type, students with different abilities and talents study together. Even if schools track children according to ability (as is the case in the Netherlands, starting from Grade 7), within each track there will still exist a range of abilities. Good education offers fitting challenges to each student, in line with their abilities and talents. Especially for high-performing students, this challenge cannot always be met within the regular class situation. On the one hand, this is due to limitations of teachers' skills, resources and administrative support (VanTassel-Baska and Stambaugh, 2005). On the other hand, there are indications that for these students, the active creation of a talent-adjusted learning environment is necessary, which is difficult to realize within one classroom, school or university (van der Valk *et al.*, 2011). For a successful approach to offer high-ability students an appropriate learning environment (including motivated peers), cooperation between schools of the same educational level and/or cooperation of these schools with institutions of the next educational level is necessary.

In Utrecht, the Netherlands, the U-Talent programme is a cooperative programme between a university (Utrecht University), a college (University of Applied Sciences, Utrecht) and 40 schools for secondary education in the region. The programme is meant to address both of the issues mentioned above: the transition from secondary school to university, and fitting education for talented students. Currently, the programme is limited to the natural sciences and mathematics, but expansion to social sciences and humanities is in preparation. Besides the two issues mentioned, the U-Talent programme is meant to provide the universities with an opportunity for the dissemination of scientific results, and for public engagement.

Within the U-Talent programme, a broad range of activities has been developed, both for high-school students and for teachers, as the latter play a crucial part in the

transition of students from high school to university. They have to equip them with the right skills and knowledge, and challenge them enough to stimulate a fruitful attitude and study behaviour. Furthermore, teachers can provide students with information on future studies and careers, so they should be knowledgeable on these topics. In this paper, however, we limit ourselves to the activities of students within the U-Talent programme.

Most activities for students include a component where researchers and students meet and interact. Examples of these activities include masterclasses for students in Grades 11 and 12 taught by researchers, guest lectures by researchers in the context of a special programme for talented students and high-school students executing their own research within a university research department. In this article, we focus on these activities, to study the motivations for the activities and the experiences of the interactions between researchers and students.

The research questions for our study are:

1. What opportunities do high-school students within the U-Talent programme have to engage with researchers in a university environment?
2. What motivations do universities and schools have for offering these programmes?
3. What motivates students and researchers to participate in the programme activities?
4. What are their experiences with these programmes in general, and with the interaction between students and researchers more specifically?

In the next section, we give a more detailed description of the U-Talent programme, including its aims, activities, organization and the involved partners. This description is used to find answers to research questions 1 and 2. Then we describe the gathering of the data we used to find answers to research questions 3 and 4, followed by the analysis of these data. In the final section, we summarize our findings and elaborate on the lessons that might be drawn from these experiences for future activities.

The U-Talent programme

History of the programme

In 2003, a small group of university science professors at Utrecht University took the initiative to start a programme for talented senior high-school students in their region. In line with discussions on the future of science education in the Netherlands, they argued that talented students were lacking proper challenges in high school, which resulted in inadequate attitudes to study and missed opportunities to become excited by new developments in science and technology. The university professors feared that science teaching in schools did not reflect what was going on in universities, leading to ineffective choices in further education. They expected that the new programme would not only result in more, and better informed, first-year university students, but also contribute to raising the level of science education in high schools, as the participating students might make their school teachers curious about their experiences, stimulating further professional development.

In 2004, the first group of 23 students from 10 schools was selected for admission to the new programme, called 'Junior College Utrecht' (JCU; van der Valk *et al.*, 2007). These students came to the campus of the university for two days per week during their final two years of high school. During these days, they were taught the regular Grade 11/12 content of mathematics, physics, chemistry and biology in less time than

in the regular school programme. In addition, they attended special lectures and workshops, and performed practical work on new developments in sciences, which were often of an interdisciplinary nature. They also had to complete a research thesis at the university, supervised by active researchers. From 2005 onwards, the number of students increased to 50 in Grade 11 and 50 in Grade 12, and more schools (28) got involved.

An advantage of this setting was that students followed all their regular and enriched courses in one place. A second advantage was that together they formed a strong social learning environment of enthusiastic and eager peers, something not experienced at their own schools. Although very successful in the view of students, the programme also had some disadvantages: (1) the number of students was small (on average two per cohort from each school); and (2) the experiences of the students had little or no impact on the rest of the school, as they never attended regular lessons in sciences and mathematics (only in other subjects).

After talks with the head teachers of the schools involved, it was decided to change the JCU programme into U-Talent Academy (UTA). From 2013 onwards, more students could participate, but they visited the university campus less frequently. At the campus, they participated only in enrichment activities: lectures, workshops, practical work and the research thesis. At their own school, students not only attended the regular science and mathematics lessons, but also followed an in-school enrichment programme together with some other talented and motivated students. In this way, far more students would benefit from the programme, and it would also stimulate all schools to innovate their teaching in the field of sciences and mathematics.

In the light of declining numbers of science and technology (S & T) students in the first decade of this century (OECD, 2006), the Dutch Government initiated several actions to increase the number of these students. At high-school level, the curricula of all science subjects were renewed and a new interdisciplinary subject 'nature, life and technology' (NLT; Michels and Eijkelhof, forthcoming) was developed. To support teachers in the implementation of these new curricula, and in order to stimulate the cooperation between secondary schools and institutes for higher education, Regional Support Centres (RSCs) were created throughout the country, where universities and colleges worked together to support science education at regional high schools. An RSC was established at Utrecht, which from the start cooperated with the JCU, for example in the development of materials for teaching NLT. The RSC offered professional development (PD) activities for teachers and short masterclasses for high-school students, to help them with their orientation for future studies in science and technology. Raab and colleagues (in press) show that the policy intervention to stimulate collaboration between higher education institutions and secondary schools has had a positive influence on the number of students entering an S & T bachelor degree.

With the creation of UTA in 2013, the RSC was incorporated, leading to one large programme, called U-Talent. Within this programme, two varieties of long-term agreements with secondary schools are accommodated, one called Ambition, the other called Connection. The Ambition schools (currently 26) are involved in the UTA, and the Connection schools (currently 14) in masterclasses. PD activities are included in both the Ambition and the Connection programmes. Schools contribute with annual fees based on the number of students in science streams and on the type of programme (Ambition or Connection). (Almost all schools in the Netherlands are financed by the government with a lump sum, with a great deal of autonomy given to the school boards.)

The U-Talent partners currently are Utrecht University with its faculties of Science, Geoscience and Medicine, and its University Museum, the Science and Technology and Education institutes of the University of Applied Sciences, Utrecht, and 40 secondary schools (see Table 1 for a summary). The partnership is settled in a long-term partner agreement including goals, tasks, responsibilities and contributions of manpower and finances. All partners are represented in a steering committee, bearing the final responsibility for the whole programme. Execution of the programme is the responsibility of the Freudenthal Institute of Utrecht University, supported by coordinators from departments and institutes, and in close cooperation with coordinators in all schools. The budget is based on contributions from the higher education institutions, the secondary schools and national project funds from the Ministry of Education. Similar networks are found at other universities in the Netherlands and they exchange experiences.

Table 1: An overview of the U-Talent partnership and programme (data for the school year 2016/17)

U-Talent partnership		
Partners	• Utrecht University • University of Applied Sciences Utrecht • 40 schools for general secondary education (26 in Ambition programme; 14 in Connection programme)	
Main aims	• Improve secondary and bachelor degree education in science and mathematics, including fitting education for talented students • Mitigate transition problems from secondary school to university • Enhance public engagement and the dissemination of scientific results from the higher education institutions	
Yearly partner contributions	• Secondary schools: €363,000 • Higher education: €723,000	
Main activities of the programme		
Activity	**Description**	**Number of participants**
Teacher PD	PD activities on mathematics and science topics for teachers from partner schools and open applicants	274
U-Talent conference	Annual conference for teachers and board members of partner schools	129
Campus days	Day visits around mathematics and science topics for students from partner schools, Grades 7–10	1,416
U-Talent Academy	For talented students from Ambition partner schools, Grades 11–12	144 – Grade 11 142 – Grade 12
Masterclasses	For students from partner schools and open applicants, Grades 10–12	384

Aims of the U-Talent programme

The U-Talent programme is dual-purpose. First, it aims to improve education in science and mathematics, both in the participating secondary schools and in the bachelor

degree phase of science programmes at the universities. Second, it intends to mitigate the transition problems from secondary school to university in order to improve results in the bachelor degree phase, in terms of both higher grades and reduction of dropout.

These purposes are specified in six goals, to which the partners agreed in their partner agreement:

1. To stimulate all high-school students to develop their science talents, by bringing them into contact with recent developments in education and research at college and university, in order to increase their motivation for sciences.
2. To contribute to the professional development of science teachers and school leaders in secondary education, by bringing them into contact with the forefront of new developments in didactics, science and business on a regular basis.
3. To cooperatively increase academic success, by establishing coherent transition conditions from secondary to higher education, and by providing future students with an adequate picture of undergraduate programmes in science and technology.
4. To contribute to the professional development of science teachers in higher education institutions, by providing them with experiences of secondary education, and the dissemination of knowledge on transition issues among college and university teachers.
5. To enhance public engagement and the dissemination of scientific results from the higher education institutions, by increasing their visibility in secondary education, and to embody the social responsibility of these institutions to contribute to the quality of secondary science education.
6. To develop a sustainable network of secondary schools, Utrecht University and the University of Applied Sciences, Utrecht, executing a set of coherent activities for all stakeholders.

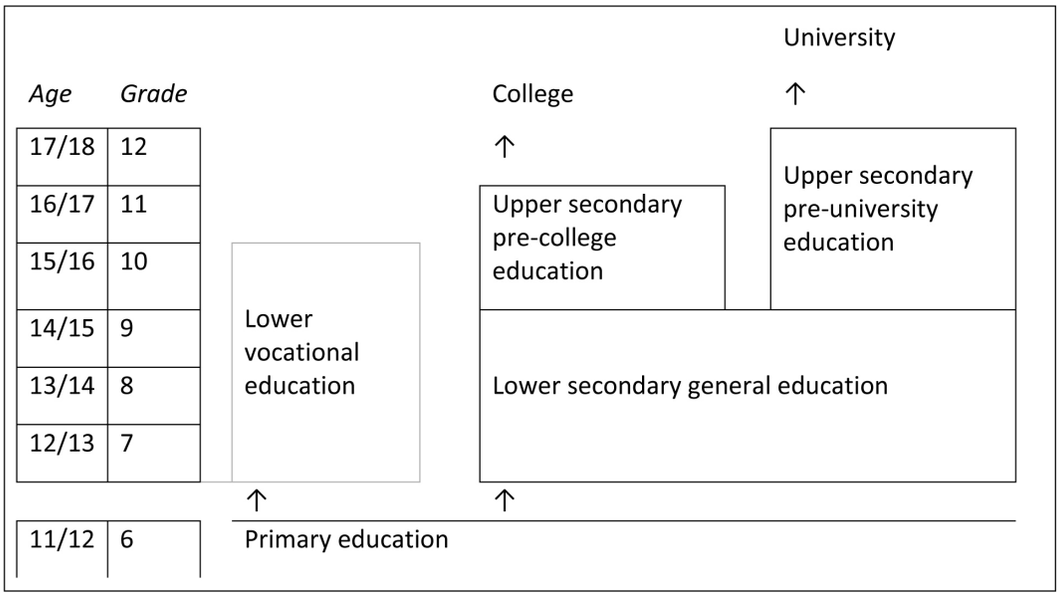
Note that these aims do not include the explicit goal to increase the number of students entering one of the participating universities: the programme aims to support students to make the right choice for their tertiary education, not to seduce them to study in Utrecht. Students who participate in the UTA do have a benefit if they enter Utrecht University, as the academy programme prepares them to enter the university honours programme at the science faculty (van der Valk *et al.*, 2017).

Activities within the U-Talent programme

Within the U-Talent programme, a broad range of activities is organized addressing the aims mentioned above. In the teacher programme, a lot of different PD activities for science teachers in secondary schools are organized. Partner schools have a fixed number of places within this programme (mostly free, sometimes for a reduced fee), but in most activities teachers from other schools can participate as well, paying the regular fee.

The student programme addresses three different groups of students: students in lower secondary general education (Grades 7–9), students in upper secondary pre-college education (Grades 10–11) and students in upper secondary pre-university education (Grades 10–12).

Figure 1: The Dutch educational system from Grade 6 (after primary education, students are tracked according to ability)



See Figure 1 for an overview of the Dutch educational system after Grade 6. In our research, we confine ourselves to the activities for upper secondary pre-university students. For these students, the main activities of the U-Talent programme are the UTA and the U-Talent masterclasses.

The U-Talent Academy is a programme designed for the gifted and motivated science student. Students from the Ambition schools can participate; a set number of places is reserved in the academy for every Ambition school, depending on the number of science students the school has in Grade 10. On average, an Ambition school can send 5 students to the academy every year, leading to a total of 150 students. In Grades 11 and 12, UTA participants come to the university for two days every six weeks. They are offered enriched science education in the form of modules on topical issues, such as nanotechnology, neurobiology, geochemistry, or simulation and games. The modules are developed at the university, and taught by selected high-school teachers. Researchers contribute to the programme in several ways, for example with guest lectures on the newest developments or laboratory work mentored by researchers from the university. Every UTA student follows six modules; every module is scheduled over two days, with six weeks in between when the student works on a project (for example, a poster presentation, a simulation or the summary of a scientific paper) that is handed in for grading. Besides following these modules, the UTA students participate in a one-week excursion to CERN, Oxford or Grenoble and they perform a short research assignment (the UTA thesis).

The UTA thesis is an obligatory part of the academy programme. All Grade 12 students in the Netherlands have to do a small piece of research as part of their regular high-school curriculum – the 'profile paper'. The UTA thesis is an extended form of this profile paper, and, as such, the thesis is not only part of the curriculum of the UTA, but also of the student's regular high-school curriculum. UTA students spend 120 hours each on their theses (a regular profile paper takes 80 hours), carrying out research in groups of three students. The central part of the UTA thesis is a four-day 'internship' with a research group at the university. In these four days, students are

supervised by a researcher (often supported by master's degree students), and the idea is to have them participate in the research being carried out by this researcher. Researchers are recruited by the U-Talent team. The researchers are asked to write a short description of their research and provide a possible research question for the UTA students to work on. All students can express their preference, and are then assigned to one of the research groups. In preparation for the internship, they study a scientific article suggested by the supervising researcher. In the research week, the students perform the core research for their theses, which can be laboratory work, data analysis or literature study (for example, for students with a thesis subject in history and philosophy of science). After the research week, the students finalize their research, write a paper and present it during a thesis symposium. Supervising researchers will be available for questions (on a limited scale) during this period.

For students in upper secondary pre-university education with interest in, and motivation for, science who do not participate in the UTA, the U-Talent programme organizes masterclasses at the university. During one or two days, the students follow lectures, labs or other activities related to the subject of the masterclass. Examples of masterclasses are: 'From mushroom to car chair', a masterclass on fungi and bio-inspired innovation; 'The synthesis of liquid magnets', on colloidal chemistry; 'IT is puzzling', on game technology and the similarities between puzzles and informatics; 'Mathematics of infectious diseases', on the mathematical modelling of epidemics; 'Being a drug designer for two days', a pharmacology masterclass on multidisciplinary drug design; and 'Weather and climate of tomorrow', on meteorology and climatology. Masterclasses can be taken by students from the U-Talent Connection partner schools. For every school, the number of places in masterclasses is based on the number of their science students in Grade 10. The school's coordinating teacher selects and registers the students, and participation is free of charge. Students from other schools (including the Ambition partner schools) can participate as well. They have to register themselves and pay a modest fee.

Data

Most of the data analysed to answer our research questions regarding the motivations and experiences of students come from U-Talent's regular monitoring and evaluation instruments. For the UTA, all participants have to write a motivation letter as part of the selection process. We analysed these entrance motivation letters for students of graduation year 2016, selected because this second UTA batch was increased to 150 students and could have been better informed by schools due to experiences with the first UTA batch. Furthermore, academy students complete a questionnaire at their entrance, at the end of Grade 11 and at the end of the academy. We selected the questionnaires from the end of graduation years 2015 and 2017 (the first and the third UTA batches – data for the 2016 batch were not available) to find clues about the experiences of the students regarding the effect of the programme in general, and the interaction with researchers more specifically. Students who register for masterclasses have to state their motivation for participating in the masterclass. We analysed these motivations for all 23 masterclasses over the past three years.

To get information on the motivation of researchers, and their experiences with participating in our programmes (UTA modules, thesis tutoring or masterclasses), we constructed a simple questionnaire and sent it to researchers who participated in the most recent school year (2016/17).

Table 2 shows an overview of the data used.

Table 2: Data sources analysed

Data source		Motivation		Experiences	
		Students	Researchers	Students	Researchers
(A) Motivation letters for admission to U-Talent Academy	GY 2016	X			
(B) Masterclass registration forms	The three years since 2014	X			
(C) End questionnaire of U-Talent Academy	GY 2015 GY 2017			X	
(D) Scientist questionnaire	2017		X		X

Notes: GY = graduation year

Data from students

While analysing the different data sources on student motivations and experiences, we established a set of categories that repeatedly appeared in the student responses (see Table 3). For some data sources, extra categories appeared during the analysis.

Table 3: Categories of motivation and experience statements by students

Category	Referring to …
Interesting and instructive	The activity or topic being interesting, and to the activity being instructive: students learning things they do not learn in the regular curriculum
Studies and careers	The activity being helpful in the orientation on further studies and careers
Peers	The social aspects of the activity, including meeting peers with the same interests and/or abilities
Doing research	The activity having a positive effect on learning about doing research and/or the activity including practical work of a different kind to the regular curriculum, or to a greater extent than the regular curriculum
Personal development	The activity stimulating personal development, including the development of general and academic skills
General experience	The activity being a good experience in general
Challenging	The activity or the learning environment being more challenging than the regular school curriculum
Increase of STEM interest	The activity having a positive effect on the student's interest in science, technology, engineering and mathematics (STEM) subjects
University	The activity being helpful for the student in getting familiarized with the university and/or in preparing the student for study at university (in general, not a specific field of studies)

Besides the classification of student answers into these categories, we looked for answers referring to the interaction between researchers and students during the activity, and the way that students perceive this interaction.

Motivations and experiences: Categories of student answers

The overall results of the analysis of the motivation statements, and the classification of student experiences into predefined categories, is shown in Tables 4a and 4b (percentages) and Tables 5a and 5b (examples of student statements).

Table 4a: Overview of students' motivation statements

Category	(A) Motivation letters UTA (%)	(B) Masterclass registration forms (%)
Interesting and instructive	52	78
Studies and careers	51	51
Peers	39	2
Doing research	37	9
Personal development	14	2
General experience		12
Challenging	45	20
University	14	18

Notes: Darker shading indicates higher percentages; the category 'increasing STEM interest' did not appear in any motivation statement.

Table 4b: Overview of students' experiences stated in responses to questionnaires at the end of the UTA

Category	(C) End of UTA questionnaires			
	Open questions 2015		Closed questions	
	Right decision (%)	Three positive aspects (%)	2015 (%)	2017 (%)
Interesting and instructive	36	38	88	68
Studies and careers	23	5	67	59
Peers	22	27	73	NA
Doing research	18	22	64	89
Personal development	16	20	NA	NA
General experience	4	13	NA	NA
Challenging	8	46	76	96
Increasing STEM interest	9	1	NA	NA
University	6	18	NA	NA

Notes: Darker shading indicates higher percentages; NA = not applicable.

Table 5a: Examples of students' motivational statements, based on open questions before UTA and masterclasses

Category	Examples of students' statements
Interesting and instructive	'I am very interested in the sciences and want to learn more' 'I hope to increase my chemical insight, which will increase my grades and improve my tutoring lessons'
Studies and careers	'It will help me to get selected for studies with limited entrance' 'I don't know what to study later, so I hope to get a better picture of a study that fits me' 'I'm going to study informatics, I hope the masterclass will give me a foretaste'
Peers	'I want to learn from contact with the most intelligent students from the region, and also how to cope with their pace of learning' 'just nice to follow the masterclass with people with the same interest'
Doing research	'I like to do research at the university with equipment which is not available at school' 'Writing a thesis at the university means being guided by researchers who will be highly motivated'
Personal development	'My level of thinking will be raised and also my social skills' 'I hope to learn who I am' 'To broaden my horizon'
General experience	'I like masterclasses' 'great experience to engage with a topic for two days'
Challenging	'I want to be challenged by in-depth learning' 'I don't have much challenges in school' 'I'd like to deepen my knowledge on quantum physics'
University	'It will give me an exclusive view of student life' 'I want to know what the academic world is like'

Motivations for participating in the UTA

Students who want to participate in the UTA have to apply at their own school for one of the places allocated to the school. Part of the application process is the writing of a motivation letter. The schools send the motivation letters of the selected students to the UTA team. From the students of graduation year 2016, 145 motivation letters from 24 schools were analysed. The number of application letters per school varied between 1 and 12. From these 145 motivation letters, 364 motivation statements were determined and classified into the categories described above. The results are shown in Table 4a, column (A): 'Motivation letters UTA'; examples of their statements can be found in Table 5a.

In their motivation letters, some students refer to earlier experiences they had at the university, attending activities organized by U-Talent for students in Grades 7–10. Others refer to being motivated by brothers, sisters, friends or fellow students in higher grades.

Table 5b: Examples of students' experiences, based on open questions after UTA

Category	Examples of students' statements
Interesting and instructive	'I learned new and interesting things' 'I gained more general knowledge on several science topics'
Studies and careers	'I know now that I want to study' 'I know that I do not want to study'
Peers	'I made new friends for life' 'enthusiastic and motivated peers' 'great learning environment with motivated students'
Doing research	'I know now what doing research means' 'I learned research skills' 'Research inspired me to apply for top universities in the US'
Personal development	'self-confidence' 'all kind of skills' 'I now dare to go to university' 'challenges in planning and organizing'
General experience	'no regrets, a great experience' 'I really enjoyed it' 'Tasks are challenging and nice' 'nice programme'
Challenging	'After attending masterclasses at the university I didn't want to go to school anymore, as the university is far more challenging' 'It challenged me to remain motivated' 'I liked the challenge and the amount of responsibility'
Increasing STEM interest	'It motivated me to work harder for the sciences' 'new vision on the sciences' 'importance of the sciences'
University	'smaller step to the university by being more familiar with buildings, working practices and required skills' 'You get a good impression of what it's like at a university'

Motivations for participating in masterclasses

Students who apply for a masterclass have to fill out a short questionnaire. One of the requests is 'Give a short description of your motivation for participating in this masterclass'. For every masterclass in the past three years, we analysed at random the answers of five students. For some masterclasses in 2016, the total number of responses was smaller than five, because in this year students who were registered by their coordinating teacher were not asked to fill in the application form. In total, we analysed 116 responses to this request. We used the categories defined above to code the answers. Some answers dealt with a variety of issues. The results can be found in Table 4a, column (B): 'Masterclass registration forms'; examples of their statements are provided in Table 5a.

In the students' motivations for masterclasses, an extra category of answers that was often mentioned (n=26) refers to the masterclass being relevant for school: students follow the masterclass as part of a special programme for talented students (n=4), as part of practical work (n=2) or for their profile paper (n=19).

Experiences of the UTA: Open questions 2015

After completing their studies at the UTA, students are asked to fill out a questionnaire, consisting of open and closed questions. In 2015, students (n=96) were asked whether participating in the UTA was (retrospectively) the right decision: 6 students answered 'no'; the other 90 students explained why they considered it to be the right decision, with a variety of positive reflections on the academy. We coded these reflections according to the categories mentioned above. Some answers dealt with a variety of issues. The results can be found in Table 4b, in the column 'Right decision'; Table 5b provides examples of students' statements.

The students that judged their decision to participate as wrong mentioned different reasons: two students did not feel at home at the academy (no contact with peers, not understood by teachers); two students did not find the modules interesting; one student found it too easy (and therefore regretted having stopped with high-level sport to follow the academy) and one student realized that science was not what she was interested in after all.

Also, the students in 2015 were asked to mention three positive aspects of the UTA. Although the answers to this question do overlap with the answers to the former question, there is a difference: in the former question, students reflect on the effect the academy has had on them, while in this question they focus on what elements of the academy they perceive to be positive. There were 95 student responses to the question, although not everyone complied in providing the three aspects requested. Again, the answers were coded into the defined categories; some answers dealt with more than one category. The results are shown in Table 4b, in the column 'Three positive aspects'; examples of students' statements are provided in Table 5b.

Besides these categories, positive effects that were often mentioned include:

- the scope of the programme and the freedom of choice (n=30)
- the social activities and excursions (n=24)
- the facilities offered by the university: labs, experts, instruments (n=20)
- the excellent teachers (n=12)
- the research thesis (n=8)
- the good work atmosphere (n=6)
- the fact that students were taken seriously (n=5).

Experiences of the UTA: Closed questions 2015 and 2017

Some closed questions in the 2015 and 2017 questionnaire relate to the categories defined above. The answers to these closed questions are summarized in Table 6.

Table 6: Answers to closed questions in the questionnaires at the end of graduation years (GY) 2015 (n=96) and 2017 (n=79) – the percentages of students that agree with the statement are provided

Category	GY	Statement in the questionnaires	Agree (%)
Interesting and instructive	2015	I found the education at the UTA inspiring	85
	2015	The content of the programme was inspiring	90
	2017	The content of the programme was inspiring	68
Studies and careers	2015	The programme helped me to find out whether a STEM bachelor suits me	67
	2017	The U-Talent Academy programme helped me in choosing my future field of studies	59
Peers	2015	Working together with students like me was inspiring	73
Doing research	2015	The U-Talent Academy made me more enthusiastic for research	64
	2017	During my thesis, I got more understanding of the way research works	89
Challenging	2015	The subject matter at the UTA was more difficult than the regular subject matter at school	76
	2017	The subject matter at the UTA was more difficult than the regular subject matter at school	96

Motivations and experiences: Interaction with researchers

In their motivation letter for admission to the UTA, 20 students refer to the expected input of university staff in the programme: 12 students have high expectations about lectures from university staff, often based on experiences during masterclasses and open days; 10 students mention that university researchers will professionally supervise student investigations at the university.

In his motivation letter for participating in a masterclass, one student refers explicitly to the expected interaction with researchers: 'Masterclasses are often taught by people with a passion for their field and it seems very interesting to me, to learn about climate from someone with a strong passion for that field.'

Experiences of the UTA: Open questions 2015

We analysed the responses to the two open questions in the questionnaire of 2015, for indications of how students thought about their interactions with researchers within the programme of the academy. While reflecting on the reasons why taking part in the UTA had been the right decision, students never explicitly referred to the interaction with researchers. When mentioning positive aspects of the UTA, however, eight students mentioned the contribution of researchers to the programme explicitly: 'lots of experts (professors, PhDs)'; 'lectures by people who work with the topics'; 'encountering researchers'; 'I enjoyed lectures from professors and was especially very impressed when they presented their own research to us'. Also, one student explicitly mentioned that working on 'real' research (as part of the thesis) was very instructive.

Experiences of the UTA: Open questions 2017

In the 2017 questionnaire, students (n=79) were explicitly asked whether they judged the input of researchers in the programme to be of added value, and 62 students agreed. Of those students, 55 answered the question about which activity/contact was most valued. Their answers include thesis supervision (n=25), guest lectures (n=21) and the support during laboratory tours, practical work, and other tasks (n=8). Five students reported the personal contacts as being the most valued element in the interaction with researchers.

Table 7a: Overview of the percentages of students' statements relating to their interaction with researchers

Category	(C) End questionnaire 2017	
	Most valued activity (%)	Most valued aspect (%)
Interesting and instructive	45	25
Studies and careers	17	3
Doing research	11	19
Personal development	8	3
General experience	2	1
Challenging	9	5
Increase in STEM interest	9	
University	2	3

Note: The category 'peers' did not appear in these statements.

For the question, 'What was the added value of the contact with researchers', 53 students answered. Their answers can be classified in the categories described above (see Table 7a, in the column 'Most valued activity'). Other categories of answer that were often mentioned include:

- the enthusiasm, passion and knowledge of the researcher (n=11)
- the practical help of the researcher (n=11)
- the insight into practice, and the relevance of the theoretical content (n=8).

Finally, all students were asked which aspect of these contacts they valued most. Again, their answers (n=73) are coded using the same categories (see Table 7a, in the column 'Most valued aspect').

Other categories of answers are:

- the enthusiasm, passion and knowledge of the researcher (n=26)
- all questions could be asked and were answered (n=15)
- the practical help of the researcher (n=10)
- the insight into practice, and the relevance of the theoretical content (n=10)
- researchers are good teachers; they explain difficult things very well (n=7)
- the personal experiences shared by the researcher (n=5).

Examples of students' statements referring to the interaction with researchers, taken from answers to both questions, are given in Table 7b.

Table 7b: Examples of students' statements relating to their interaction with researchers, from the questionnaire at the end of the UTA for graduation year 2017

Category	Data source	Examples of students' statements
Interesting and instructive	Most valued activity	'You get really interesting knowledge and experiences from researchers' 'The modules became more interesting because someone talked about his field of knowledge'
	Most valued aspect	'They talk about their own research, which is very interesting'
Studies and careers	Most valued activity	'The contact with university teachers and researchers helped me in choosing my field of study' 'It gives you more insight into jobs'
Doing research	Most valued activity	'A clear image of what research is about and what the life of a researcher looks like'
	Most valued aspect	'To learn how much effort research takes' 'It teaches us what the work of a researcher looks like' 'It gave you a unique view into the world of research, which was inspiring'
Personal development	Most valued activity	'We learned a lot on how to write a research paper' 'the awareness of the value of knowledge'
General experience	Most valued aspect	'lots of variation'
Challenging	Most valued activity	'I could go as deep as I wanted, because I could always ask more'
	Most valued aspect	'They lifted it above the regular school level'
Increasing STEM interest	Most valued activity	'I got motivated for topics I wasn't interested in before'
University	Most valued activity	'The tours show you what university life is really like'

Data from researchers

Of 71 researchers, 16 responded to the open-ended questionnaire about their motivations for, and experiences with, U-Talent activities. The majority of them (n=9) were involved in the regular UTA education (for example, giving guest lectures and laboratory tours); the others supervised a thesis (n=4) or gave a masterclass (n=3).

Motivations that researchers gave for their participation in the U-Talent activities are:

- general experience, challenging (n=9)

  'I like to teach'
  '[It is a] nice challenge to develop something for high-school students'

- promoting research (n=6)

  'It is important for high-school students to get in touch with real research at a laboratory'
  'To stimulate young intelligent people for a scientific career'

- outreach and publicity for a department or bachelor degree programme (n=3)

  'My department saw it as publicity for our bachelor programme'

- public engagement/dissemination of scientific results, as a societal responsibility (n=3)

  'It is important to interact with the community'

- personal contacts (n=5)

  'My supervisor asked me to do this'
  'I know the organizer'.

Other motivations that were mentioned once or twice were: 'Students ask intelligent questions'; 'I like to share my own enthusiasm'; 'The outreach activity is valued by the university and for research grants'; 'I would have valued it myself, when I was in high school'; 'The interactions can be useful for students in deciding what they want to study after they finish school'; 'I was involved in the development of the module, so I want to be involved in teaching it as well'.

The researchers report the following positive experiences:

- the enthusiasm of the students (n=10)
- instructive for the researcher (n=7)

  'I learned a lot myself'
  'It gave me a new view on my own field of study'

- general positive experience (n=3)
- contact with high-school students (n=3)
- useful (n=2)

  'The students produced a nice data set, which we will surely use for our research'.

Conclusion and discussion

Opportunities for U-Talent high-school students to engage with university researchers

For high-school students, the main activities within the U-Talent programme in which they can engage with researchers are: (1) the U-Talent Academy (UTA), a programme for gifted and motivated students in Grades 11 and 12; (2) the UTA thesis, a research project during which students do a short 'internship' within a research department; and (3) U-Talent masterclasses, intensive one- or two-day courses on topical issues, organized by university departments for students in Grades 11 and 12.

Motivations for universities and schools to offer these programmes

From the partner agreement, we derive the following set of institutional motivations for these programmes:

(1) the stimulation of science capacity among high-school students in order to increase their motivation for sciences, by bringing them into contact with recent developments in research and education
(2) the increase of academic success by:
    (a) bringing coherence to the transition from high school to university, with respect to scientific knowledge and skills, and academic competencies
    (b) providing the student with a more realistic perception of science bachelor degree studies at university
    (c) providing researchers (who often are also bachelor programme teachers) with a better insight into the capacities, interests and educational experiences of entering students
(3) the stimulation of the dissemination of scientific results and of public engagement with university research.

Motivations for students and researchers to participate in these programmes

Students' main motivations for participating in both the UTA (including the thesis) and the masterclasses are the interesting and instructive characteristics of the programme, its challenging nature and the orientation it offers for future studies and careers. Applicants for the UTA also mention the expected cooperation with peers, and the expected amount of research and practical work.

Researchers' main motivations for participating in the U-Talent activities are their own pleasure in teaching these students and the promotion of scientific research.

Experiences of the programmes, including the interaction between students and researchers

UTA graduates report positive experiences in the following main categories: the programme was interesting and instructive; it was more challenging than the regular curriculum; it helped them to choose their future field of studies; they met and worked with peers with the same interest; and it gave them a thorough introduction to doing research.

Most students find the interaction with university staff a valuable aspect of the programme. When asked to describe the added value of interacting with researchers, students mentioned most of the categories defined above, except the peer category. Additionally, the students note as positive: the enthusiasm, passion and knowledge of the researchers; the practical help provided by the researchers; the insight researchers give into practice, showing the relevance of the theoretical content; and the fact that researchers answer all the students' difficult questions.

When comparing the motivations and the experiences of the students, it has to be taken into account that the motivation letters had a selective function, which motivated students to prove to the selection committees that they were suitable candidates. The questionnaire afterwards did not involve such high stakes, of course.

Researchers report the enthusiasm of students as their main positive experience from the U-Talent activities. Also, they found the interaction to be instructive for themselves.

Closing remark

It is likely that the transition between secondary and higher education is an issue in many other countries, as is the need to challenge talented students beyond the regular curriculum. We would appreciate contacts with institutions and networks in other countries, as we believe that an exchange of experiences will be of mutual benefit.

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