Innovative Teaching


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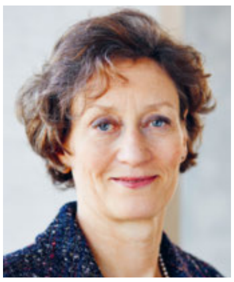
Dear readers

Education is Switzerland's most important natural resource. It is therefore no coincidence that education is listed first in Switzerland's federal act concerning the various purposes of its two federal institutes of technology. We take this commitment very seriously at ETH Zurich. We strive continuously to improve our teaching methods, so we can provide our students with the best possible education.

Over the past 20 years, new technologies have significantly changed the way we teach. Today we can offer completely new educational formats and methods to prepare young people for their professional careers and their roles in society. These innovations allow us to take students' individual learning styles into account, and to impart new skills and expertise that are playing increasingly large roles in the working world, such as project work.

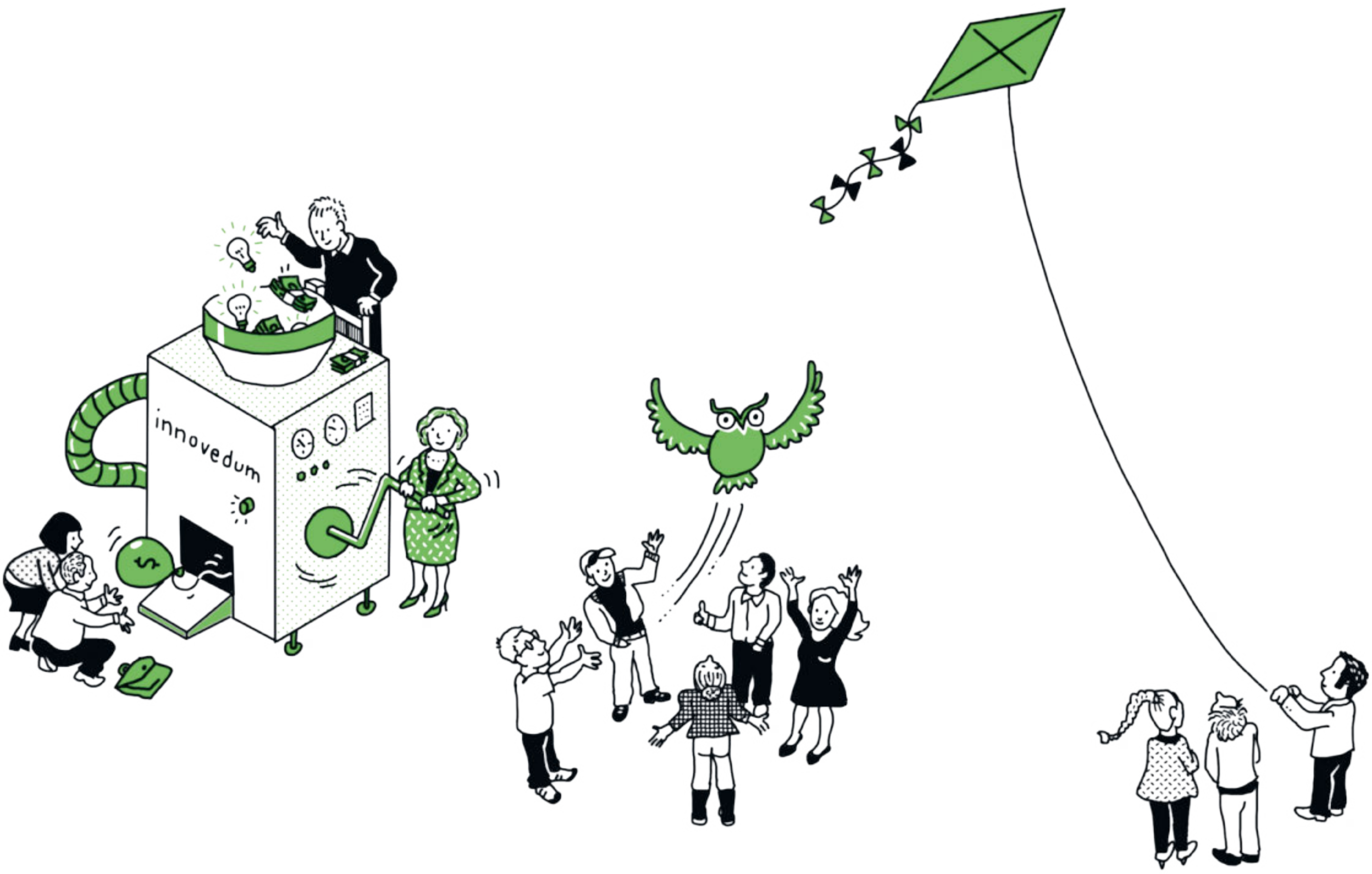
In this publication, we aim to show you how we at ETH Zurich foster innovative teaching. We also hope that the projects presented here will encourage other professors and lecturers to try out new ideas.

Constantly rethinking and improving education calls for a considerable investment of resources. I therefore wish to extend my deep gratitude to all our professors and lecturers who invest their time and energy, as well as all the employees who lend them their strong support. Finally, I would like to thank all our donors – public and private alike – who make these projects possible.



Prof. Dr. Sarah M. Springman

Rector of ETH Zurich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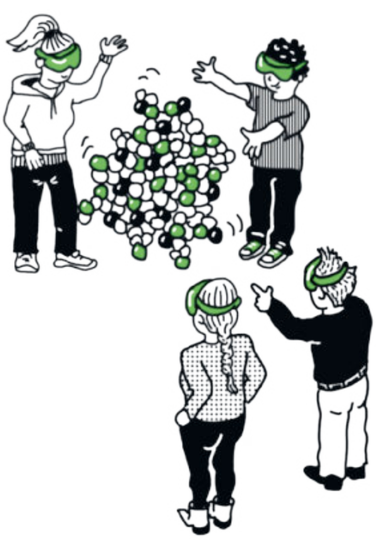


Guest article

Alignment of teaching practices with disciplinary practices

Prof. Dr. Manu Kapur · **How innovations in teaching facilitate the transfer of theoretical knowledge into professional practice.**

The main goal of teaching at universities is to equip students with the requisite knowledge, skills, and dispositions that enable them to work effectively in their professional careers. This assumes that students are easily able to transfer what they learn at the universities to their professional practice. However, decades of research on human cognition and learning consistently show that transfer is not only hard but rare.

Take an engineering student, for example, who may have learned advanced differential calculus, yet find it difficult to apply it to solve engineering problems in practice. Or a medical student, who crams in a lot of knowledge about anatomy, yet finds it difficult to remember it soon after the final exam, let alone use it for diagnoses during clinical practice. Or a science student, who learns a lot of science knowledge, yet may be lost when asked to conduct scientific inquiry using that very knowledge.

What is common across these examples? They all show a lack of transfer from school knowledge to disciplinary practice. That is, although students learn substantial amounts of formal, content knowledge in the domains, they find it difficult or are often unable to use this knowledge in the authentic practices of the domain. Why does this happen? Are our students not particularly bright? After all, experts lament that no matter how clearly they explain the concepts to their students, it baffles them why students still do not "get it".

> "We need to innovate in ways that are consistent with, and advance, the science of how people learn."

Rethink how we teach

Research in the sciences of human learning suggests that a lack of transfer is not as much a problem with the student as it is with their learning experience. In formal schooling contexts, this means that transfer is a function of how we teach our students. Any innovation in teaching would do well to address the problem of transfer. And this is where we need to rethink how we teach. We need to innovate, but not for the sake of innovation per se. Instead, we need to innovate in ways that are consistent with, and advance, the science of how people learn. Although research in the cognitive and the learning sciences suggest several principles for designing effective teaching and learning, I focus on one key principle any innovation in teaching would do well to embody. Allow me to illustrate the principle with a thought experiment. Imagine a carpenter wants to train his son or his daughter to learn the craft. Does he first make his child learn all the relevant knowledge from mathematics, because well, one needs arithmetic and geometry in carpentry? Does he also make his child learn all the relevant concepts in Physics, because knowledge of forces and equilibria is also critical for carpentry? How about throwing in some material science, communication skills, business management, and creativity courses in the mix too. And when his child has not only learned all such knowledge, and passed examinations that test this knowledge in contexts that have little to do with carpentry, only then he brings his child to his shed and engages him/her in the practice of carpentry. Hopefully not. Instead, the carpenter is more likely to take his child to the shed, and engage in the authentic practices of carpentry. All knowledge and skills that the son learns is situated in the actual practice of carpentry. This is what knowledge-in-use looks like.

“An obvious implication is to solve the problem of transfer at its root.”

Coupling domain knowledge and disciplinary practice

Part of the problem with modern education systems is that we have intentionally divorced domain knowledge from the disciplinary practices of its use. Having ourselves created the problem, we then lament that our students find it difficult to transfer what they learn in school to disciplinary practices. I do not mean to be flippant, but I do paint an extreme case contrast to bring out the point. To be clear: domain knowledge and skills are important. They need to be taught. And experts need to teach them. The problem is that we are teaching them in ways that tend to decontextualised and misaligned with the disciplinary practices within which such knowledge will be used. An obvious implication is to solve the problem of transfer at its root. This would mean aligning the practices of schooling with the practices of the discipline. Of course this is easier said than done, but then why should one expect the problems of learning to necessarily admit easy solutions. Returning to the examples, if design is a core engineering practice, then engineering knowledge and skills ought to be situated in the design process. This does not mean all knowledge is learning through the design process. What it means is that the design process then provides the context and the motivation for learning. Students should be engaged in design for the most part, which anchors their learning.

Likewise, if a core medical practice is differential diagnosis, then medical education should be anchored on differential diagnosis as the core activity. Medical students should be engaged in differential diagnosis, and most of their knowledge gets learned in the process of performing diagnoses. And likewise for other domains as well. Although I have taken the liberty of reducing a domain to one core practice, each domain is likely to have multiple core and peripheral practices. The point is that innovations in teaching should engage in the process of backward design.

Backward design process

By backward design, I mean starting with the end in mind. For example, what are the core professional practices of engineers? What do engineers really do? How does knowledge-in-use look like, that is, what kinds of knowledge, skills, tools and resources do they use in performing these practices? Once we have sense of what the disciplinary practice of engineers looks like, we can then design the teaching practices in alignment with the disciplinary practices. The same goes for other disciplines as well. What do doctors really do? What do scientists do? What do lawyers do? And so on. And then design the teaching practices in alignment with the professional practices in the domains.

Practical constraints will of course limit the degree to which alignment between teaching and disciplinary practices can be achieved. Still, it is instructive to use alignment as a key guiding principle when designing innovations in teaching. A typical counter to the above proposal goes something like: "but students need the knowledge and skills first before they can apply". Mind you, that is falling back into the trap of decoupling domain knowledge and disciplinary practice – the very trap that we must try to avoid.

A couple of additional benefits of alignment are noteworthy. An analysis of disciplinary practices, especially knowledge-in-use, is likely going to result in a radical rethinking of and reduction in the amount of content knowledge that we focus on in the curriculum. Speak with an engineer or a doctor, and you will find that knowledge-in-use is typically a very small subset of the knowledge acquired during training. Likewise for other domains as well. Focusing primarily on knowledge-in-use should free up time for redesigning the curriculum, teaching and learning in alignment with the disciplinary practices.

Explicit and tacit knowledge

A second benefit of alignment is a better coupling between explicit and tacit knowledge. Explicit knowledge is knowledge that can be externalised, represented, codified, and communicated. Laws, principles, theorems, formalisms, and so on are examples of explicit knowledge. Tacit knowledge is something that cannot be externalised, let alone be codified or communicated. There are often times when an expert intuits, or is unable to explain how he or she thought of or did something, especially when engaged in disciplinary practices. It is one of those things that cannot be "taught", but can be "caught", yet it is absolutely essential for expertise development.

Research on expertise suggests that experts have not only large body of explicit knowledge but also highly-nuanced, situational, tacit knowledge. Expertise is a function of how experts are able to leverage both explicit and tacit knowledge to solve problems. Knowledge-in-use, therefore, is a coupling of explicit and tacit knowledge.

If the primary focus on schooling remains on explicit knowledge, then it will hinder the development of expertise. If, however, innovations in teaching can embody the coupling of both explicit and tacit knowledge, it will positively influence the development of expertise. Taken together, alignment can facilitate the coupling of explicit and tacit knowledge, which in turn, will increase the likelihood of transfer as well.

Prof. Dr. Manu Kapur

Manu Kapur has been Professor of Learning Sciences and Higher Education at ETH Zurich since 2017. Previously he taught and researched in Hong Kong and Singapore. He is known worldwide for his work on "learning from failure".

KITE Award

Letting ideas take flight

Every two years, the Lecturers' Conference of ETH Zurich confers the KITE Award for key innovation in teaching at ETH Zurich (KITE). Endowed with 10,000 Swiss francs, the KITE Award is given to ETH teaching staff by ETH teaching staff. It honours innovative teaching approaches that improve students' learning and so help to increase the quality of education. The KITE Award underscores the importance that ETH accords teaching, raises its profile outside the university – and encourages professors and lecturers to forge new paths.

In 2018, 27 projects were submitted. The four that made it to the final round are presented on the following pages.

Dr. Lukas Fässler · Dr. Markus Dahinden

Self-paced learning in big classes

Computer science is required for most courses of study at ETH, yet many students start their first semester with almost no prior knowledge. Lukas Fässler and Markus Dahinden overcome this difficult starting position with a tailored teaching concept.

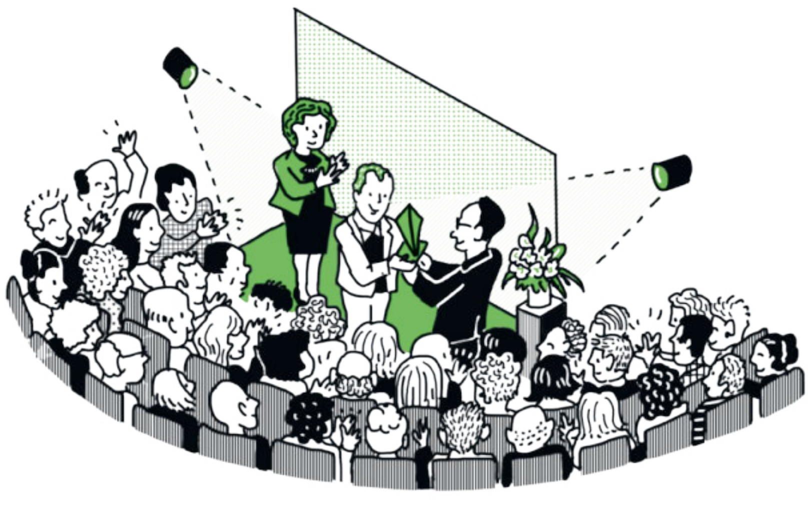
Making a virtue of necessity: that is what Lukas Fässler and Markus Dahinden do, together with David Sichau from the Department of Computer Science at ETH Zurich, with their E.Tutorials project. They teach the basics of computer science to over 800 first-semester students from five different departments. Some 90 percent of the students, all of them prospective engineers and scientists, have hardly a clue about computer science – and many did not expect it to be compulsory. For this reason, their enthusiasm often has its limits.

Instead of cramming computer science basics into students' heads during an introductory lecture, the lecturers give them hands-on tasks right from day one – well, if a virtual programming lab counts as hands-on: "Our students get to grips with the basics of computer science in a way that's fun but effective," Fässler says. With real data from their specialist subjects, they solve a practical problem, such as containing the spread of an illness, calculating an ocean current, or checking the effects of a medication in a patient's blood.

Students are guided by an E.Tutorial that they can adapt to their individual needs. "They can choose the level of support the e-tutorial provides by adjusting the course to their knowledge. In addition, they can test their knowledge for themselves," Fässler says, adding: "Thanks to the individualised support system, they quickly become independent."

> "Our students get to grips with the basics of computer science in a way that's fun but effective. Thanks to the individualised support system, they quickly become independent."

The E.Tutorials project plays a key role in the indispensable training in digital skills at the undergraduate level.•



From left:
Dr. Markus Dahinden,
Dr. Lukas Fässler

Prof. Dr. Volker Hoffmann

Sustainable action starts with critical thinking

In Volker Hoffmann's course on corporate sustainability, the students do more than ruminate on concepts – they also learn to review them critically and put their knowledge into practice. As future managers, they should be able to use these skills to make companies more sustainable.

In the Corporate Sustainability course taught by Volker Hoffmann, ETH Professor of Sustainability and Technology, 150 to 200 students from various disciplines train to become experts in sustainable management. At the same time, they can enhance their potential for academic research.

What is innovative about the course is that the students do not simply memorise the theoretical concepts of sustainability; instead, they are required to think critically about the material and apply their knowledge in a practical way.

Assessment, strategy, technology and finance are the topic areas that previously were communicated primarily in a lecture format. But three years ago, Hoffmann made some fundamental changes to the course. Now, during the first half of the semester, he supplements the lectures with interactive videos and e-modules that foster skills like critical thinking. Hoffmann also makes use of the six-sentence argument (6SA) method, which helps students learn to craft persuasive arguments. In the second half, the students apply their newfound knowledge in one of the four areas. Small groups supported by coaches use specific examples of companies in the water, energy, mobility and food sectors to prepare debates, draft consulting strategies, calculate economic models and produce campaign videos.•

Prof. Dr. Volker Hoffmann

"Just knowing the facts is no longer enough"

Prof. Dr. Edoardo Mazza

Edoardo Mazza is a Professor in the Department of Mechanical and Process Engineering at ETH Zurich and President of the Lecturers' Conference, which confers the KITE Award. A native of Italy, he studied and earned his doctorate at ETH, and then worked in management in industry from 1997 to 2001. He also heads a laboratory at the Swiss Federal Laboratories for Materials Science and Technology (Empa).

Professor Mazza, why is the KITE Award necessary?

By giving the award, the Lecturers' Conference aims to recognise the outstanding work many professors and lecturers are doing. It simultaneously underscores our duty to our students to constantly improve our teaching.

What makes teaching "innovative"?

One way is to incorporate the new ways students have of working and make use of novel teaching aids. Another is to apply new approaches for improving communication between professors, lecturers and students.

To what end?

Today, it is no longer enough to memorise facts, learn skills and know how to use instruments. As one of the world's top universities, ETH Zurich must offer students the opportunity to synthesise knowledge from various disciplines, test methods on complex problems and think critically about theories. Students, in turn, have to learn how to work in interdisciplinary teams; for example engineers with biologists and materials scientists with medical students. For tomorrow's managers, such skills are becoming more and more important.

How do you approach your own teaching?

I try to constantly improve my courses, although I still write with chalk on the blackboard during the introductory lectures. I also let students participate in my interdisciplinary projects, and that has worked extraordinarily well.

What do the teaching staff think about the award?

They think it's excellent. The second year we asked for nominations, we received 27 submissions, which is more than we got the first time around. The proposals come from all ETH Zurich departments and cover a range of exciting ideas and progressive approaches. And all the departments are involved in the selection process.

How do you envisage the future of the award?

I hope it will become a tradition. The innovative concepts should be more widely known and should motivate all professors and lecturers, at ETH Zurich and elsewhere: we want to make it so all Swiss universities can benefit from them. We also want to stimulate the discourse about quality university teaching, and the KITE Award definitely plays a part in that. •

Prof. Dr. Stefano Brusoni · Dr. Alan Cabello

An interdisciplinary path to the prototype

Design thinking: this process-oriented method helps students quickly solve problems and develop ideas. Stefano Brusoni and Alan Cabello have systematically integrated this method into ETH Week.

Collaborating in large, interdisciplinary groups to solve a real-life problem in a short amount of time is not something students do every day. Yet that is precisely the setting for ETH Week. First launched in 2015, it offers students a rich educational experience with a view to their future tasks in business and society.

At ETH Week 2017, whose theme was Manufacturing the Future, 180 ETH students from all departments developed prototypes intended to improve current production methods. Sustainable use of materials and resources was made a central issue in order to take potential social consequences into account.

In 2017, the design thinking approach was systematically integrated into ETH Week. The idea was the brainchild of Stefano Brusoni, Professor of Technology and Innovation Management at ETH Zurich and Alan Cabello from Spark Labs. "The multi-stage and process-oriented method brings students into contact with experts, so that they may identify problems and brainstorm new ideas for solving them," Brusoni says.

Budding mathematicians, physicists, environmental systems scientists, chemists, biologists, computer scientists, architects and engineers worked in groups of roughly ten people. After ceaselessly reviewing their ideas and concepts for six days, they presented their prototypes. One of these was edible packaging for foodstuffs that are quick to spoil, and another was a 3D printer that recycles plastic.

The students received support from graduates of previous ETH Weeks. As tutors they see to the group dynamics, and as facilitators they keep the group's eyes on their goals. •

From left:
Dr. Alan Cabello,
Prof. Dr. Stefano Brusoni

Dr. Katja Köhler · Prof. Dr. Ernst Hafen

Learning together instead of listening to lectures

Center for Active Learning: Katja Köhler and Ernst Hafen use this facility to make teaching an interactive team effort, in a move away from lone lecturers to group learning.

All too often, teaching at universities is a lonely prospect: the lecturer orally presents the material to a large group of students and hopes that they will understand and retain it. Students, for their part, are more or less satisfied with the information that they are offered, and note it down diligently, but they usually find collaborative work in the lab and in practical exercises more exciting.

It is precisely this team aspect that Katja Köhler, educational developer in the Department of Biology, and Professor Ernst Hafen, the department's Director of Studies, are bringing to teaching from their research. In 2016, they founded the Center for Active Learning (CAL), in which doctoral students and undergraduates can help professors and lecturers to develop new methods and implement interactive formats. One of these is the flipped classroom, where students use videos and other materials to familiarise themselves with the material in advance, so that time in the classroom can be devoted to more in-depth insights and discussions. Another is learning analytics – quantitative data on students' learning behaviour. This allows students to review their progress, and professors and lecturers to react accordingly during lessons. As a result, education becomes more interactive. The new formats have been well received: "Surveys by the Association of Biology Students indicate that the student body appreciates these activities. They actually wish there were more interactive courses," Köhler says.

To date, 22 professors and lecturers have joined CAL and 9 courses have been reworked. CAL is also part of the Biology Study Center, where students can work on problems with lecturers, and it supports the Book Club, in which first-semester students can discuss extracurricular popular-science books.

Overall, CAL has made a good name for itself among ETH's biologists. However, Hafen points out that "basically, every department at ETH can benefit from CAL. It takes less than one percent of a department's budget to make a major improvement in its teaching." The first joint projects with other departments are already underway.

From left: Prof. Dr. Ernst Hafen, Dr. Katja Köhler

An award for exceptionally committed professors and lecturers

The Golden Owl honours professors and lecturers who offer their students excellent teaching. Since its inception, the award has been presented by the VSETH students association. Anyone at ETH with a teaching assignment is eligible to win the Golden Owl. Each year, one professor or lecturer in each department is selected by students to receive this mark of their approval. Golden Owl winners are also automatically nominated for the Credit Suisse Award for Best Teaching, which goes to one professor or lecturer each year.

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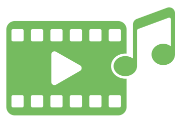
Computer Science · Prof. Dr. Vanessa Wood, Information Technology and Electri- cal Engineering · Marc Alexander Wüest, Environmental Sciences

Fostering the reinvention of education

Milestones from
18 years
of fostering innovation

2000



The virtual botany field trip
One of the first Innovedum projects was VirtEx, an e-learning tool. The project allowed students to obtain extensive insights into botany with the help of a DVD, and is able to provide much more information than other media (books, herbariums).

Do-it-your-soil
This e-learning course on soil protection (sustainable soil management) includes many interactive animations. First developed in 2000, the follow-up project is still in use today.

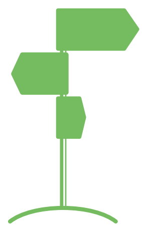
2001

mt_EAST
In mt_EAST, students from different universities worked together on a common architecture project. They used a media table featuring a touchscreen, internet connection and webcam to draft design plans.

2002

Flipped Classroom
The Fonds Filep supported a flipped-classroom project on programming. As the name suggests, the traditional set-up is reversed: usually students learn in the lecture hall and do exercises at home. In a flipped classroom, they learn at home and come to the university to do the exercises. ETH's first flipped classroom was in 1998, in chemistry courses.

2005



First degree programme initiative: Mobility matters
Teaching staff at ETH Zurich can propose new degree programmes or suggest changes to existing ones. The first such initiative focused on the topic of mobility between Bachelor's and Master's programmes. It created a web-based e-learning tool for three departments.

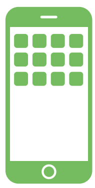
Institutional support of educational innovations has long been a feature of ETH. What used to be the Fonds Filep – launched in 2000 as part of the ETH World strategic initiative – is now the Innovedum fund (Innovedum is a portmanteau of innovation and education). This fund places two million Swiss francs annually at the disposal of the Rector to support initiatives that further develop education at ETH. Over the years, this money has financed the planning and implementation of over 150 innovative projects that have gone on to shape the nature of teaching at the university today. Innovedum supports an impressive variety of projects, ranging from digitalisation in the classroom to an increased focus on skills and interactive learning. Uniting all these projects is the fund's overarching goal: to continually adapt the exceptional learning environment to the prevailing needs of students and teaching staff, so that ETH graduates become independent critical thinkers who are equipped to shape the future.

More information: www.ethz.ch/innovedum-projects

2007

Electronic exams
With the help of the Innovedum fund, a program was developed to help staff design exams flexibly and give and grade them electronically. The project also contained a database of exam questions.

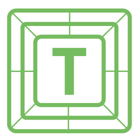
2012



App for students
An app was funded and developed for the first time: EduApp helps ETH students in their everyday lives (time management, maps, study rooms) and also enables feedback in the classroom (clicker questions).

2013

Massively online for the first time
MOOC stands for massive open online course: a free online course in which thousands of people can participate at the same time. MOOCs consist of videos and online exercises and exams. The first MOOC at ETH Zurich concerned robotics and was also used in preparations for the ETH course on the same subject.



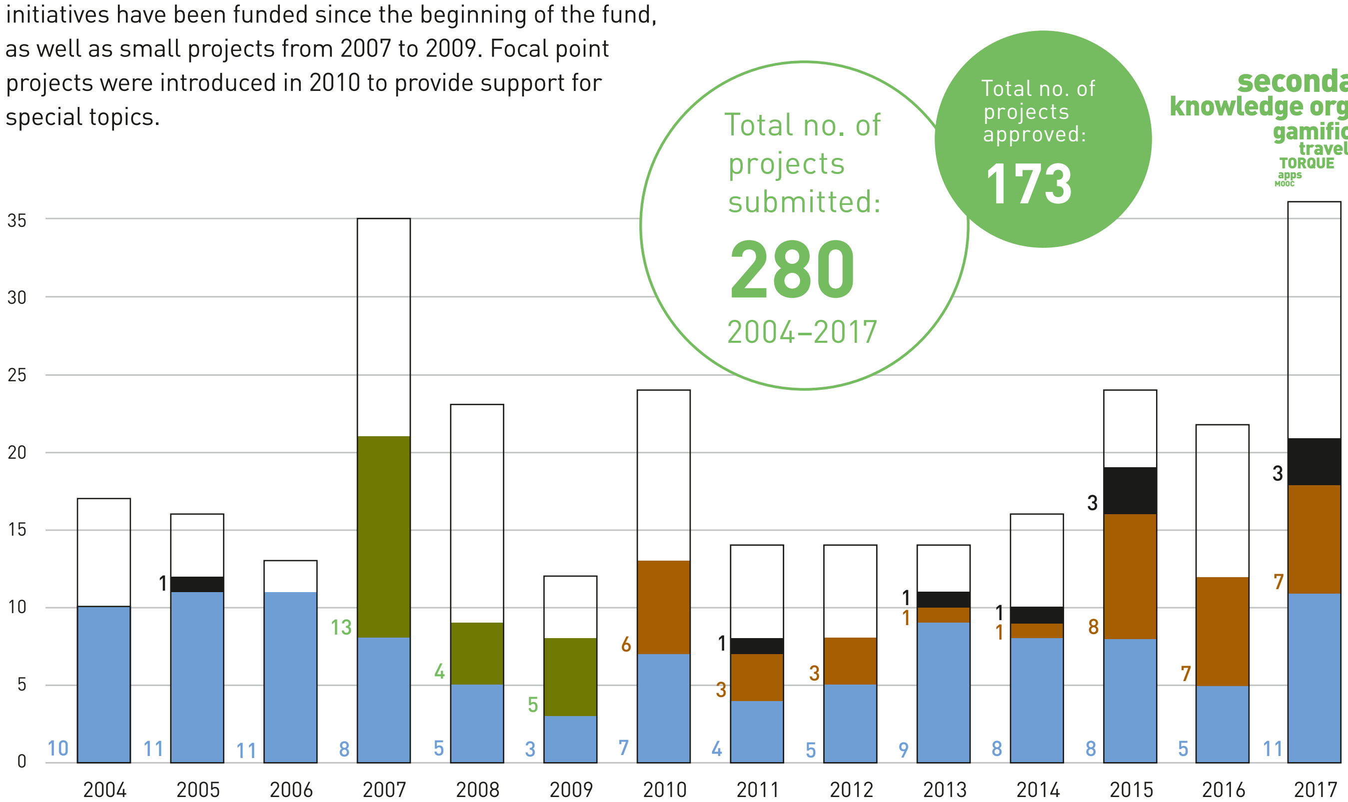
The first course launched as a TORQUE
In TORQUEs (tiny, open-with-restrictions courses focused on quality and effectiveness), students learn a large portion of the course material on their own from videos. Additional scripts, links to external sources, forums and quizzes are available online. This leaves more class time for discussion. The first course to be designated a TORQUE offered an introduction to "R", software for statistical computing.

2015

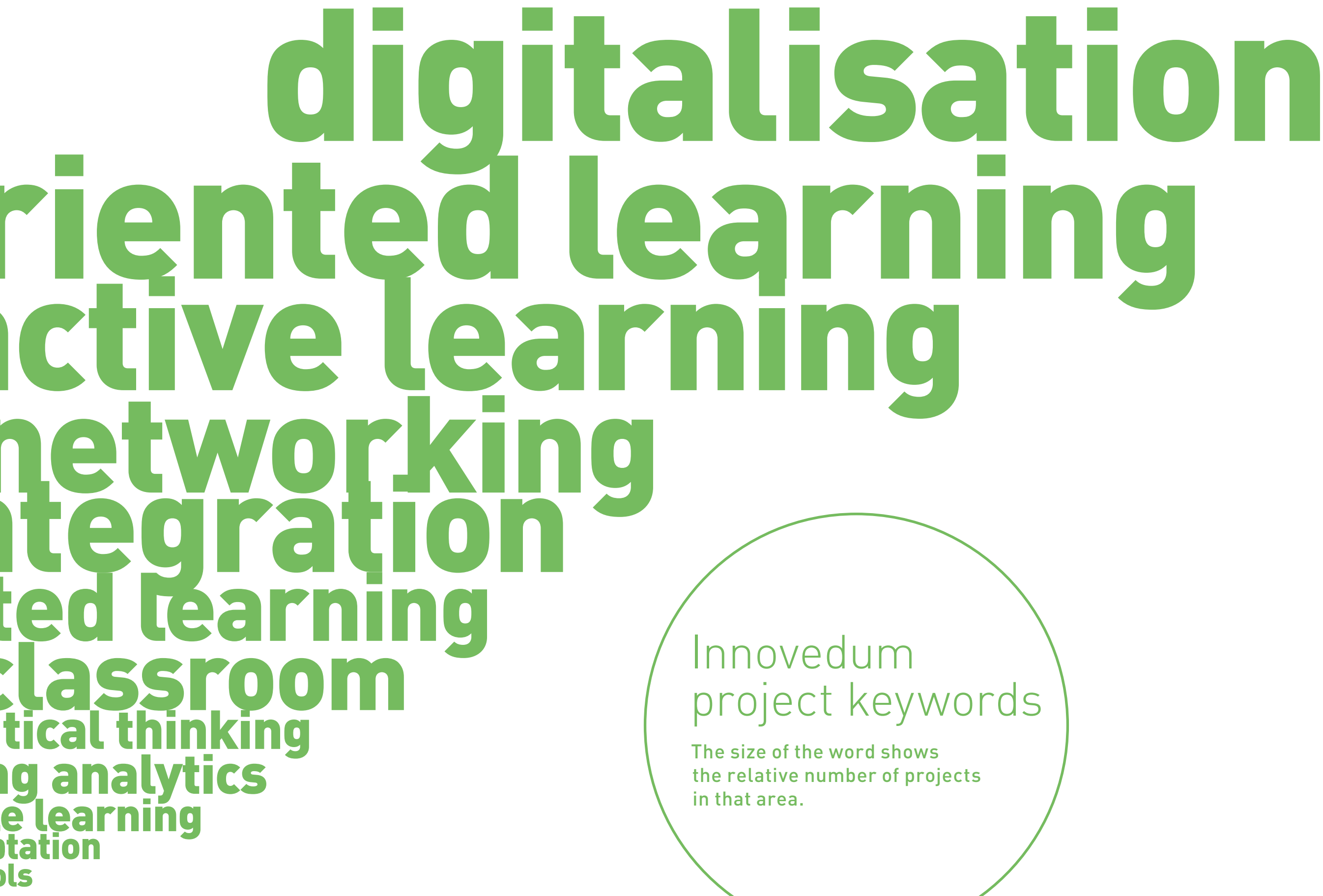
Optimising courses in real time
Online tool PELE – the Personal Electronic Learning Environment – gives lecturers the unprecedented ability to systematically optimise their courses in real time with the help of electronic data. Every week, the lecturer tracks how much time the students spend on tasks, noting where they progress quickly and where they have problems.

Versatile and multifunctional

The type of projects that receive support has changed over the years. Teaching projects and degree programme initiatives have been funded since the beginning of the fund, as well as small projects from 2007 to 2009. Focal point projects were introduced in 2010 to provide support for special topics.



	Total no. of projects submitted (incl. unsuccessful proposals)
TEACHING PROJECTS	Innovative projects that aim to improve the quality of courses at ETH Zurich
SMALL PROJECTS	Projects with simple approval procedures and a budget of less than CHF 30,000
FOCAL POINT PROJECTS	Projects for promoting certain topics (e.g. interactive classes)
DEGREE PROGRAMME INITIATIVE	Through such initiatives, the content of existing degree programmes can be adapted or entirely new ones developed

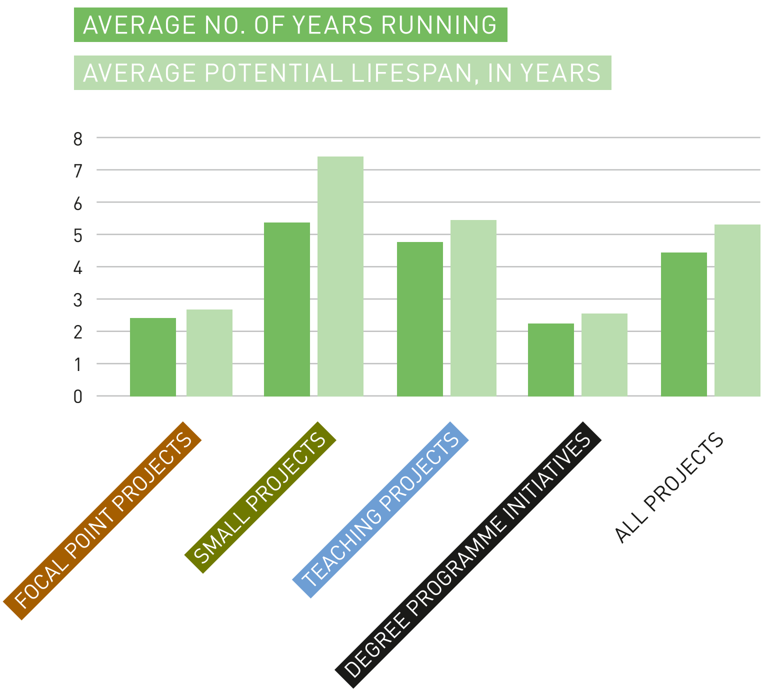


Innovedum project keywords

The size of the word shows the relative number of projects in that area.

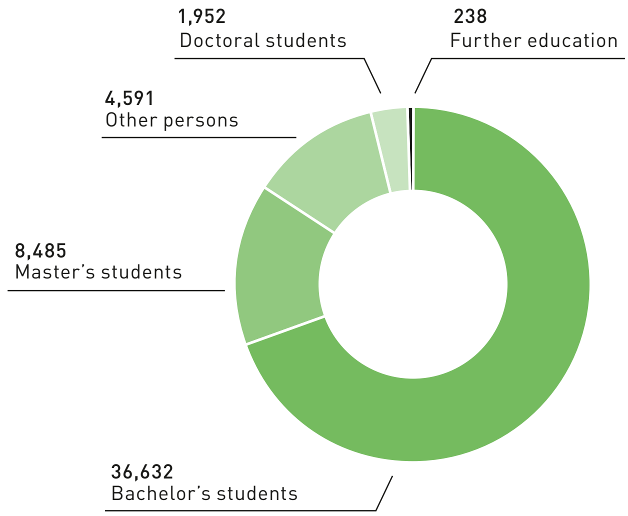
In it for the long haul

Innovedum projects are not only innovative, they are usually sustainable, too – in use for years after the project was started. This graphic shows how many years projects have actually been running, compared to their estimated potential lifespan. For all four project types, the rate is a pleasing 70 percent. *



In use at all levels

All in all, some 50,000 people have benefited from Innovedum projects, especially those at the undergraduate level. The figures are based on the project proposals. *



* Graphs reflect years 2004–2015

Learning how to develop medication through board games

Jörg Goldhahn and his team from the Department of Health Sciences and Technology have developed a board game that provides students with an insight into the complexity of drug development while simultaneously creating a new type of examination.

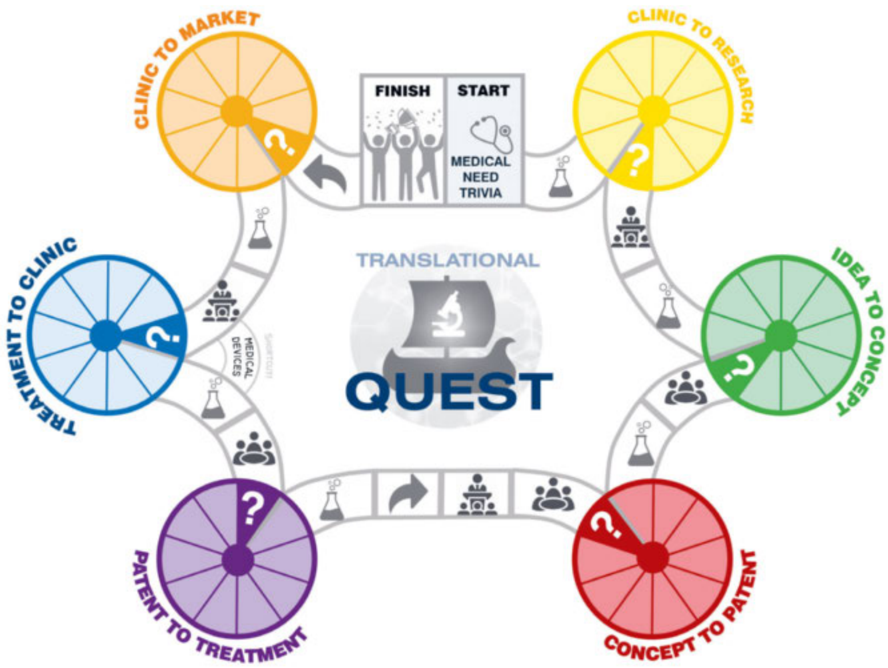
The project has its origins in the old familiar question that students ask professors and lecturers at the start of every course: What's going to be on the test? If it's a multiple-choice exam, for instance, then students can revise by looking at old homework assignments. The type of examination thus has a major impact on what and how students learn.

"That's why we wanted to create a completely new testing set-up," says Jörg Goldhahn, Professor in the Department of Health Sciences and Technology. "And we wanted to develop an exam that not only asked takers to regurgitate information, but would also test their skills, such as creativity." Goldhahn, who teaches translational science, tackled the task together with his teaching assistants Ursula Brack, Kathrin Studer, Séverine Chardonnens and Stephanie Huber.

Translational science concerns itself with building bridges between basic research and practical applications, such as taking new findings from the lab and translating them into a medication available from the chemist. It is a very complex process: on the one hand there are factors that drive the process forward, such as the accelerated approval of the medication by a drug authority. On the other there are factors that slow the process down, such as setbacks from a clinical study. The primary objective of Goldhahn's course is to teach students this process and highlight the legal aspects. "I believed that a lecture format alone would not be enough to accomplish this," he says.

That's when the idea of a game emerged. Goldhahn and his team assumed that students enjoy playing games, which would be an intriguing vehicle for conveying knowledge. Besides, games often produce a group dynamic that can be leveraged to improve the learning effect.

Goldhahn and his assistants developed a board game that, similar to Monopoly, illustrates a cycle, since developing a medication is also cyclical in nature. The most import-



Playful learning:
The drug development life-
cycle as a board game.

ant thing was to highlight the various interrelationships at play, and for the game to be used for the exam.

The task quickly became more complex than expected – or as Goldhahn put it: "Fortunately I didn't know at the outset what we were in for..." There are thousands of pages in the literature on games, but using a game as an exam? Hardly anything. How can a game be used to see if students have grasped the interrelationships in question? And most importantly, what can be on the test? How can a game get people to demonstrate their creativity, and then evaluate it? Goldhahn assigned his students the task of working in groups to design a card for the game with an inhibiting or an accelerating factor.

Some of the resulting ideas were surprising – even for Goldhahn, a translational science expert. Still, grading the cards was no easy task. One reason was the sheer volume: more than 1,000 cards needed to be evaluated. Another was the content: how can you rate creative ideas on an objective grading scale? To grade the cards fairly, Goldhahn and his team developed an internal peer-review process.

What did the students think of the game idea? The vast majority loved the unusual format, thought the idea interesting and were thrilled that at the end of the day they would not be required simply to study for a major exam. However, there were also some students who found themselves at a loss with this format, and would rather have had a "classic" exam.

After one round, the project is not yet finished: a group of students has adopted the game and wants to further develop and market the prototype. How does the project leader feel about his idea? "It was a fun and instructive experience. And it's certainly a promising format for supporting traditional lectures," Goldhahn says. The project has also met with international interest and was presented at the International Congress on Medical Education in Abu Dhabi, March 2018.•

Prof. Dr. Jörg Goldhahn

Jörg Goldhahn, who has been Privatdozent (Senior Lecturer) at the Department of Health Sciences and Technology since 2008, was named Adjunct Professor at ETH Zurich in 2015. He is Deputy Head of the Institute of Translational Medicine and project manager for the innovative Bachelor's course in medicine, which was established in 2017.

More educational opportunities

At ETH Zurich, education is in constant flux, as it is continually adjusting to the latest state of knowledge. Currently there is a clear trend towards project-based and interactive teaching.

Before classes began at ETH on 16 October 1855, the founders pondered several issues, among them what educators should focus on when designing a curriculum. Technical drawing, measuring, mathematics or on the practical requirements of industrial production?

"None of the courses of study from that time have remained in their original forms," says Andreas Vaterlaus, Professor of Physics and Education and Vice-Rector for Curriculum Development. He continues, "Even if certain subjects, such as analysis in mathematics, have had the same name for a long time, the content and methodological focuses have changed time and again." Indeed, when it comes to reworking existing curricula or developing new offerings, many of the questions from back then are still relevant today.

ETH Zurich currently offers 23 Bachelor's and 45 Master's degrees, but these are constantly evolving. "Research is always providing new insights, sometimes of such a fundamental nature that they open up completely new research directions – and teaching is always adapting to the new state of knowledge," Vaterlaus says. He has been overseeing this evolution as Vice-Rector for Curriculum Development since 2012. It usually takes place as a series of many small steps, such as eliminating certain specialities.

Less frequent are larger steps, such as completely overhauling a degree programme. "When this happens, there is nothing left of the original plan," he explains. And sometimes entirely new programmes emerge, such as the Bachelor's degree in medicine, which ETH established recently.

If departments want to launch such a major change, they can submit a degree programme initiative via the Innovedum fund to receive financial support. One to two such initiatives are submitted each year for review by the Teaching Commission (see inset).

The Teaching Commission invites the submitter(s) to present their idea in person, and they then proceed to discuss it in depth before making their recommendation to the Rector. Ultimately it is the Rector's decision to fund the degree programme initiative or not.

In Vaterlaus's experience, the degree programme initiatives are "well thought out and already broadly discussed in their departments". In discussions within the Teaching Commission, criteria such as feasibility, chance of success and firm anchoring in the department play a major role. For example, the department needs to have enough teaching staff to handle the degree programme. "We want to keep teaching expertise in house, and not outsource too many teaching assignments," Vaterlaus explains. In addition, a degree programme initiative must also be in keeping with the overall strategic orientation of teaching at ETH.

And who inspires initiatives like this? The catalyst for the AGROfutur initiative (see inset) was a study of the labour market by the Swiss Association of Agronomists and Food Scientists. It showed that companies in the agro-food business were generally quite satisfied with ETH graduates, but saw room for improvement in their communication, social and methodological skills.

Representatives from the private sector as well as students participated in reforming the degree programme. Both groups would like students to obtain more practical and career-relevant experience before graduation. One of the ideas that resulted from their collaboration was to make a 16-week work experience placement an integral part of the Master's degree. The companies agreed to assign the interns interesting tasks and provide mentoring and support. Students, too, saw great added value in a programme with such additional dimensions, even though the reforms made the programme longer by one semester.

In materials science, by contrast, the rapid pace of development in the research field and changes in the department spurred the administration to realign the degree programme. Over the next three years, the department aims to flesh out a modern curriculum that equips students for future professional challenges. The plan for reaching this goal is to place more emphasis on engineering and design while maintaining academic rigour. Examples of what this might look like in real life include subject-specific projects in which students focus more on problem-solving than previously and can participate more directly.

Both initiatives demonstrate the general direction in which teaching at ETH is moving. "It's becoming increasingly important to combine a solid grounding in science and technology with application-oriented and practical aspects. In general, there is a tendency towards project-based and applied teaching with more open and interactive formats," Vaterlaus says. •

The Teaching Commission at ETH Zurich

The Teaching Commission is an advisory body of the Executive Board. In the context of ETH Zurich's development as a university, it is responsible for managing innovation in teaching and learning. Its primary task is to support teaching innovation and projects within the framework of Innovedum. The Teaching Commission is chaired by the Vice-Rector for Curriculum Development, Andreas Vaterlaus. Every area of ETH is represented on the Commission by a professor, and other seats are held by doctoral students, students, and the Educational Development and Technology department.

Prof. Dr. Andreas Vaterlaus

Andreas Vaterlaus has been full Professor of Physics and Education at ETH Zurich since 2008, and was elected Vice-Rector for Curriculum Development in 2012. In this role, he supports the Rector in matters concerning curriculum development and innovation processes.

Daring to leave some gaps: redesigning two Master's programmes

The Master's degree courses in pharmacy now teach less material – instead, they allow more time for case studies, independent work and clinical modules.

The learning objectives of the traditional pharmacy curriculum at Swiss universities are set out in the country's Medical Professions Act. They have recently been adapted to better deal with the shortage of general practitioners. "The idea is that pharmacists will play a greater role in basic care in future. For example, they are set to carry out certain vaccinations and act as the first point of contact for patients," says Professor Cornelia Halin, Director of Studies for the pharmaceutical sciences, who is overseeing the degree programme initiative.

"We want to spend less time stuffing our students' heads full of encyclopaedic knowledge, and instead give them more time to learn how to obtain that knowledge for themselves and to evaluate specific cases."

"These changes to the law have given us an opportunity to make a sweeping overhaul of both our Master's programmes," Halin says. For the MSc in Pharmaceutical Sciences, more weight is now given to learning how to approach scientific models and data critically, while the classical Master's in pharmacy will focus more on developing problem-solving skills.

"We want to spend less time stuffing our students' heads full of encyclopaedic knowledge, and instead give them more time to learn how to obtain that knowledge for themselves and to evaluate specific cases," Halin says. The decision to cover fewer topics but in more depth requires courage to risk leaving some gaps. However, students apparently appreciate this courage, if the positive feedback from the two new Master's programmes that started in 2017 is any indication.•

Prof. Dr. Cornelia Halin

Cornelia Halin studied biochemistry at ETH Zurich and earned her doctorate in pharmacy there. After a postdoc at Harvard Medical School, Boston, USA, she returned to ETH Zurich, where she became Assistant Professor of Pharmaceutical Immunology in 2008 and an Associate Professor in 2014.

Materials for self-directed learning instead of lectures

The new concept for Renate Schubert's lecture course aims to make learning more active – and puts the focus on students' ability to apply economic knowledge to practical, topical issues.

More than 500 students take the economics course, which until recently was held in the traditional lecture hall. "Now the entire group meets only twice or three times a semester," says Renate Schubert, Professor of Economics. At the other class times, students meet in five smaller groups to solve problems and discuss exercises with one another. For students who do not want to actively participate in group work, Schubert continues to offer the traditional format, with room for 200 people.

"Before, the students saw only me – now the entire team is involved."

Schubert and her colleagues coach the groups. "Before, the students saw only me – now the entire team is involved," she says. Her team members find mentoring and coaching students as tutors to be a rewarding experience.

Students prepare for their small groups with self-directed learning materials: short video sequences that convey Schubert's course material. The videos contain five to six slides that sketch out key economic concepts. A "magic hand" directs the viewer's attention to important details, and Schubert's lectures provide the voiceover.

The videos are embedded as TORQUEs (tiny, open-with-restrictions courses focused on quality and effectiveness) in an electronic learning environment, which also includes exercises, current media reports and discussion forums. "One valuable side effect of this realignment is the intensive interaction and debate we are observing among students from various departments," Schubert says.

Prof. Dr. Renate Schubert

Renate Schubert is Professor of Economics and the ETH President's Delegate for Equal Opportunities. In 2006, she founded the Institute for Environmental Decisions (IED), which she headed until 2014. Since 2015, she has also led a research group at the Singapore–ETH Centre. Her TORQUE project made it to the 2016 final of the KITE Award.

Sharing ETH Zurich knowledge with the world

With his Future Cities course, Gerhard Schmitt shares the latest knowledge on urban planning with people around the world – people who would otherwise have no opportunity to learn this information.

"A city is more than just buildings, streets and sewers – it also possesses a complex metabolism," explains Gerhard Schmitt, Professor of Information Architecture at ETH. The problem is that in the past, city planning did not take people enough into account; it was rather people who had to adapt to the conditions in a city. Schmitt and his colleagues from the Future Cities Laboratory, a large-scale ETH research programme in Singapore, want to share a different approach with the urban planners of tomorrow.

The challenges in urban development are enormous, especially those facing the rapidly growing cities in subtropical and tropical areas in Asia and Africa. Experts believe that over the next few decades, homes and jobs will need to be found for another two billion people in these regions. One example is the city of Shenzhen, north of Hong Kong, which over the past 30 years has grown from a fishing village to a metropolis of more than 12 million people. Challenges present themselves on two levels: how to finance this growth, and how to keep development sustainable. After all, cities in Europe and the US are still far from being sustainable – how can one expect these rapidly growing cities to be?

"Over the years we have acquired a great deal of knowledge about urban planning in our ETH departments, and we're able to conduct research projects from an Asian perspective in Singapore," Schmitt says. "Now we want to share this knowledge where it is most needed: in the cities of Asia and Africa. But how?"

Schmitt decided to create a MOOC, or massive open online course, and named it Future Cities in reference to the name of the research programme. MOOCs are free online courses consisting of videos, exercises or forums where participants can discuss topics online. All someone needs to take the Future Cities course is an internet connection. "Anyone can take part," Schmitt says, "no matter where they live, no matter what level of schooling they have. We felt that was important." In four years, Schmitt and his team have created four courses: Future Cities, Livable Cities, Smart Cities, and Responsive Cities. Each lasted 9–10 weeks. Participants spent about 1–2 hours per week on the courses, more during practice and exam phases.

In total, over 110,000 people from more than 160 countries registered for the courses. Even if only a fraction of them stayed with the course to the end and earned the certificate, the advantages of MOOCs are clear: they make it possible to share knowledge with the world, with people who are interested in the subject but have no other way to

From left: Kees Christiaanse and Gerhard Schmitt record a MOOC (massive online open course).

access well-prepared, high-quality information. However, there are certain drawbacks: With so many participants, more in-depth discussions between professor or lecturer and student are simply not possible. And lecturers can provide personal contact and direct coaching only to a very limited extent over the internet. A MOOC thus cannot replace actually attending a university course.

Schmitt and his team have attempted to foster connections between participants by assigning them various tasks. One of these was to make the invisible in their city visible. Similar to a wall that keeps an electric wire hidden, the depths of a city contain much that is normally unseen – such as all kinds of wires, cables and pipes. These stay hidden until a construction site reveals them. "Our students sent in thousands of pictures, and then evaluated and commented on them," Schmitt says.

Another task was to improve the spatial arrangement of buildings in a slum using a modelling program. For this purpose, the Future Cities team developed a programme that is free of charge, does not require a lot of computing power and can be opened via the internet. The participants submitted thousands of designs. In turn, they had the opportunity to evaluate and comment on each other's projects.•

Prof. Dr. Gerhard Schmitt

Gerhard Schmitt is Professor of Information Architecture and Director of the Singapore–ETH Centre. Until 2017 he was Associate Vice President for ETH Global. From 1998 to 2008, he served as Vice President for Planning and Logistics and Member of the Executive Board at ETH Zurich. Prior to that, he was Professor for Architecture and Computer Aided Architectural Design (CAAD) at ETH Zurich. His research and teaching focus on the simulation of future cities, artificial intelligence in architecture, and spatially distributed collaborative design.

An app that fosters connection

The EduApp – one of the most successful Innovedum projects – has been enhancing classes at ETH since 2012 by fostering interaction between professors or lecturers and their students.

Lecturers initially attempted to get students more involved in lecture courses by using "clickers". These allowed them to ask the students questions during class, similar to a quiz. "The clickers worked really well as far as creating a picture of the students' progress goes. But you needed a deposit to borrow one, they were often left lying around and got lost, or the batteries went dead," recalls Marinka Valkering, an educational innovation expert in ETH Zurich's Educational Development and Technology administrative department (LET).

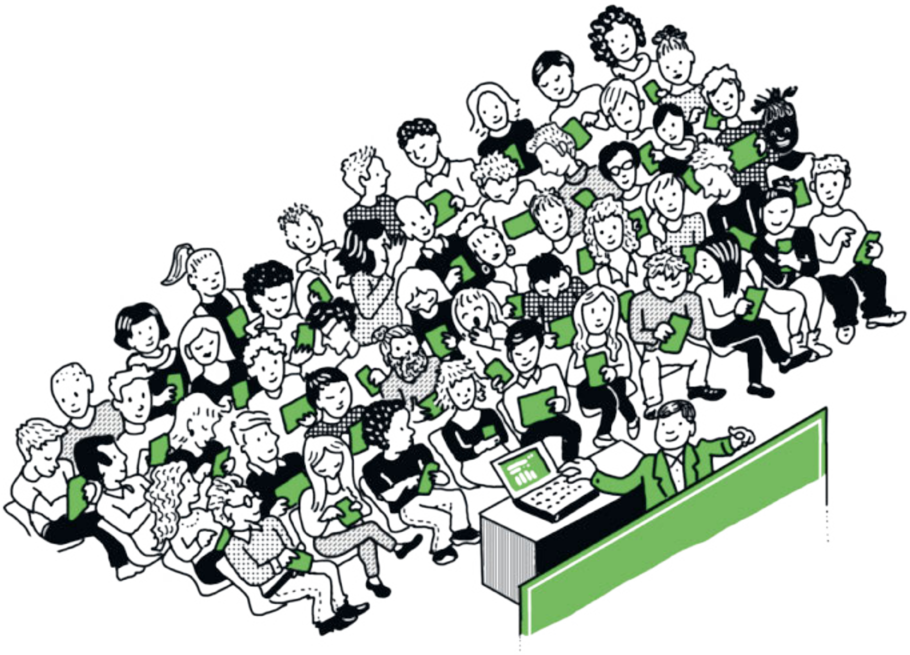
This led two of her LET colleagues to come up with an idea that would allow students to answer the clicker questions on their laptop, tablet or smartphone. They also wanted the application to feature other interactive functions and support students in their everyday routines.

The first version of EduApp was piloted in the classroom in 2012. It contained not only a student's personal schedule, but also things like a campus map with floor plans of the buildings and event spaces. "That's how first-semester students found their way to events," Valkering says.

Since then, the application has steadily expanded. If anyone is looking for a room to study or do group work in, they can check EduApp to see if a suitable space is nearby.

Professors and lecturers can benefit from numerous EduApp functions, too. "The main goal is to foster interaction with students in large lecture courses," Valkering says. Besides the clicker questions, this happens on two channels. One is the course forum, which functions much like a group chat where students can ask questions about the course and discuss them with the professors or lecturers or their colleagues.

"The questions have proven to be a good way of involving the students more in the class."



The second is semester feedback: a survey that asks students for their impressions of the course. As the survey is given six weeks into the course, lecturers can adapt their materials if necessary while the semester is still ongoing. In Autumn Semester 2017, a total of 112 surveys collected over 60,000 responses.

But professors and lecturers use the clicker function even more: last year, a total of 10,807 students in 155 different courses submitted more than 267,000 answers. The clicker questions can also be enhanced with images or formulas. "The questions have proven to be a good way of involving the students more in the class," Valkering says. But professors and lecturers have to plan enough time for them. For instance, it makes sense for students to talk amongst themselves before they submit their answers.

The lecturers project the submitted answers on the screen before discussing with the students which is the correct one and why. Crucial to the learning process is the type of clicker question: simply asking for facts leaves students feeling unchallenged. "Questions that encourage reflection and uncover potential comprehension problems are better," Valkering says.

Constantly expanding EduApp makes the software ever more complex, pushing it to its performance limits. As a result, over the last two years ETH's IT Services has completely redesigned EduApp. "This increased its stability and enables us to further enhance the app in the future," Valkering explains.

In cooperation with the Association of Students at ETH and the teaching staff, Valkering has already drawn up a list of requests for additional functions. "Now we have to look at our budget and decide which requests we can fulfil," she says. The goal is to bring out a new version every year. In Valkering's view, EduApp should maintain its clear focus on use in teaching at ETH, but it could be expanded to coach students on study habits, say, or help them with time management.•

Marinka Valkering

Marinka Valkering studied Applied Educational Science and Technology at the University of Twente in the Netherlands. She initially joined ETH Zurich as an educational developer in the Department of Biology, before becoming an education innovation expert in the Educational Development and Technology administrative department.

PELE scores – an online tool for quality control

Students don't benefit from end-of-semester course evaluations – and professors and lecturers quickly forget the lessons learned. Online tool Pele can help: it makes it possible to optimise a course while it is still ongoing.

About 500 students and one lecturer in a lecture hall – not a simple set-up for an experiment. How can the lecturer be sure that the students who attend the course and spend around 90 percent of their learning time on the computer understand the material? And how can the students get face-to-face feedback from the lecturer to help them move forward?

Online tool Pele – the Personal Electronic Learning Environment – provides the solution. Developed by Lukas Fässler, Markus Dahinden and David Sichau from the Department of Computer Science at ETH Zurich, Pele makes it possible to provide students with real-time support. Every week, the lecturer tracks how much time the students spend on their tasks as they prepare for the lecture on the computer, noting where they progress quickly and where they have problems and are getting stuck. With the large amount of statistical data gathered, the lecturer can respond to students' performance and adjust the requirements of the examination.

But Pele also helps out the students. During the semester, they meet six times with a teaching assistant who gives them face-to-face feedback in a conversation lasting about 15 minutes. Students can in turn evaluate this feedback via Pele. If a teaching assistant is frequently given a poor rating or always scores extremely well, the lecturer takes a closer look and does a quality check of the large learning system in the interest of the students. "Pele turns lecturers into pilots who have an overview of the students' learning progress and the quality of the assistants' work," Fässler says.

Dr. Lukas Fässler

After receiving his doctorate at the Department of Computer Science, in 2013 Lukas Fässler became a computer sciences lecturer for natural sciences students at various departments. He heads teaching projects and is committed to teaching computer science at the interface between upper secondary school and university.

Teaching and innovation

Everyone is talking about the future of universities. For centuries, the aura of an ivory tower clung to these institutions, but now there is hardly a stakeholder in society that is not concerned in some way with their tasks and potential. School administrations and politicians, professors and target groups in business and local government – many see institutions of higher learning as a necessity, especially when it comes to mastering the challenges of digitalisation. The tendency is to rely primarily on excellent research – and not without good reason. In contrast, discussions about teaching have subsided. Aside from some culturally pessimistic complaints about the drawbacks of the Bologna Process and occasional references to the impending replacement of our lecture halls with online offerings (called MOOCs), little is being said. This is regrettable, as teaching can indeed play a crucial role in the quality of an institution.

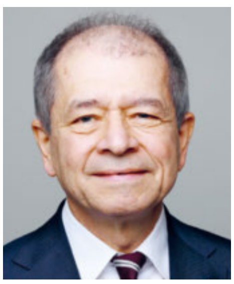
The past

Up until the 18th century, universities were financed by the local ruler as places for disseminating professorial knowledge. Their main emphasis was on theory, although all branches of study were careful to ground theoretical knowledge firmly in professional practice: "high" subjects such as theology, jurisprudence or medicine enjoyed a higher status than those studied by "artists" (the forerunners of philosophers and scientists), which were accorded only an introductory function. In the 19th century, three models established themselves in Europe, where they have shaped our understanding of the university right up through the end of the 20th century: the German Humboldtian model; the Anglo-Saxon liberal arts education; and the French engineering education system.

"While digitalisation may call into question the means of knowledge transmission, the core function of university education remains intact!"

Humboldtian education saw itself as a means for passing subject-specific expertise on to future academics, with university studies the ideal means of obtaining that education. In contrast, the Anglo-Saxon model opted for a broader canon of content, the teaching of which aimed mainly to embed the graduates successfully in society (citizenship). As for France's engineering universities (grandes écoles), their goal was to prepare elites for service in the public sector. In Switzerland, too, this development had an impact, which we can still recognise in the organisation of education at our universities: in Basel, Zurich and Bern, the universities embraced the Humboldtian model's wide array of subjects on offer, whereas ETH emphasised engineering expertise and preparation for higher technical professions – areas important to the young confederation.

These historical differences have affected the way students regard their university education. For example, in the Anglo-Saxon view (now adopted worldwide), they do not question the principle of selectivity in university admissions based on an open-ended application process. This is bound up with the idea that the quality of a university can also be measured by the quality of its students. Continental Europe takes a completely different approach, as the idea of the right to study – ideally through a selection-free process – was dominant here for a long



Prof. Dr. Antonio Loprieno

Since 2000, Antonio Loprieno has been Professor of Egyptology at the University of Basel, where he has also been Professor of the History of Institutions since 2015. In addition, from 2006 to 2015 he was Rector of the University of Basel, and from 2008 to 2014 he was President of the Swiss Rectors' Conference (CRUS; now called swissuniversities). Loprieno is active in a number of universities, a member of various internationally significant scientific societies, and co-publisher and editor of a variety of scientific publications. He has been President of the Austrian Science Board since 2016, and President of the Swiss Academies of Arts and Sciences since 2018.

time. Such asymmetry in the relationship between students and institutions has two important consequences: First, universities that are permitted to select their students can adapt their offerings to supply and demand better than those for which a selective approach is an unknown concept. Second, quality in teaching is given more weight in the Anglo-Saxon system than in the European one.

Current trends

For twenty years, the European university landscape has been attempting to reconcile the differences between these models. The Bologna Declaration (1999) brought concerns about the quality of academic teaching to public attention across Europe. Authorities introduced a formal study architecture that prescribed the ideal sequence: (general) education at the Bachelor level, followed by (professional) training at the Master level. Humboldtian as well as technical universities in continental Europe have now formally adopted this new study architecture, but in reality they adhere to the model of a compact discipline-based education. We do not generally view the Bachelor's degree as an education in its own right; what qualifies a graduate for a profession is the subsequent Master's degree.

My initial feeling is that this will change in future: Bachelor's and Master's degree programmes will be organised less sequentially. We will not be able to avoid placing greater value on undergraduate education and redesigning it to serve as better preparation for several Master's programmes. An excellent example of this shift is the new Bachelor in medicine at ETH: not only scientific, but computational expertise too is becoming ever more necessary at the undergraduate level if students are to benefit fully from studying an applied subject, such as clinical medicine at the graduate level. The trend is clear – a basic general education for the Bachelor's degree, specialisation for the Master's.

The emergence of competition has altered the course of the past two

1973
Students attend a lecture in a large hall on the Hönggerberg campus.

decades' debate around the role of universities. With the growing importance of efforts to raise third-party funding, and the proliferation of research KPIs and international rankings, an idea of "excellence" has arisen, based on the Anglo-American model of the globalised world-class university. Although the actual information these indicators provide has often been called into question (and rightly so), the pressure on universities to compete for greater visibility has genuinely increased. This development has created a hierarchy of institution quality in the public perception: 15 years ago, the differences between a general university and ETH were clear to see in the courses they offered. Today, however, no one in Switzerland would question the superior quality of ETH – ultimately based on rankings.

Where is university education headed?
As a result of this shift, the view of the university is changing. Whereas teaching in all three historical models was viewed purely in terms of disciplines, growing attention to rankings is increasing the importance of looking at the university as a whole. In addition to research, teaching is also becoming a key factor in the formation of an institutional identity. But how exactly can teaching create such an identity?

A university's range of activities and its sphere of influence can be understood as a coordinate system with the axes of knowledge and application. Near the intersection of the two is what could be termed "learning" or "basic education". The differentiation of the last 15 years has spurred a move toward strategically manageable options: is the emphasis in research and teaching to be mainly on scientific excellence, as in the model of top Anglo-American universities, and thus with positioning along the knowledge axis? Or should these activities focus more on the needs of the labour market, as politics and industry often expect, and move along the application axis? Of course, a university's overarching strategy must give due consideration to both impulses. By aiming for a precise position

2016
Active learning in groups. In a "flipped classroom", students discuss the material they learned for themselves at home.

somewhere in between, an institution may well create its own USP.

However, the dilemma these two axes pose also entails a certain risk for university teaching. A focus on raising third-party funds or on how to approach the quantitative measurability of research performance could induce a university to abandon the education of students as its primary mission. This risk is present in Central Europe because we are completely unfamiliar with the American liberal arts colleges or the French grandes écoles – institutions that enjoy broad acceptance in society, but do little to no research. For us it is different: research and teaching belong together, and in a qualitative sense as well. At a research-intensive institution such as ETH, I believe the solution to this dilemma lies in innovation – prioritising both outstanding research and its translation into specific commercial applications. Of course, the most important conduit for the transfer of research findings is the university's graduates themselves; and the more innovation is made a feature of their learning experience, the better the transfer.

But what does "innovation", a word that originally had economic overtones, mean when applied to teaching? How do I distinguish between short-lived, fashionable trends that I do not necessarily need to follow, and long-term developments that I need to take into account for the purposes of innovation? The burgeoning significance of technological innovation is particularly plain to see in the case of MOOCs, a shift that seems to herald the end of the sovereignty of "book learning". But a word of caution: while digitalisation may call into question the means of knowledge transmission, the core function of university education – the interaction between teachers and learners – remains intact!

Digital development has implications that reach far beyond the technological aspects and impacts the very nature of study. The first of these is the transition from understanding knowledge

1955
Internship in the machine laboratory. Students designing aircraft.

as something individual to viewing it as something communal. Traditionally, our teaching is based on the premise that lecturers convey “their” personal knowledge – either from the front of a classroom or in an interactive setting. The digital transformation is now confronting us with a different understanding of knowledge, which is no longer administered by a person, but by a community. This requires professors and lecturers to approach their role with a new mindset. Digitalisation has theoretically put each of us just three mouse-clicks away from a revelation worthy of a Nobel prize; as a result, teaching's primary focus is shifting from the transmission of knowledge to how to manage it. How can we, through excellent teaching, provide our students with tools that enable them to assess independently the scientific integrity and plausibility of the knowledge transmitted to them? That is the core challenge of good teaching at a research-focused academic institution.

Digitalisation's second implication for teaching derives from the first, and extrapolates its effects to the level of society in general. The digital transformation puts all knowledge at our disposal unfiltered – not just high-quality information, but unfortunately unscientific knowledge as well. This means that for teaching at a university to be truly excellent, it must transcend the purely subject-specific dimension. When they go out into the world, graduates need to be not only experts in one particular subject, but scientifically trained young people ready to take their place in their communities. Only then will first-class universities be living up to their responsibility to society.

2015
Project work. Students are given a practical task to sharpen their design and product development skills.

But what is it like in the real world?

One project for hundreds of first-year students? The Department of Mechanical and Process Engineering proves that it works. Mirko Meboldt and his team took over the Innovation Project in 2012 and continue to develop and refine it.

Mirko Meboldt, a professor of product development, is a champion of the intersection where theory meets practice. Not only because the professional world needs appropriately trained engineers, but also because the practical application of theoretical knowledge heightens the learning effect. It is this intersection that lies at the heart of his Innovation Project course.

Mechanical engineering students working in groups on new mechatronic systems.

Split into groups of 5, 500 second-semester mechanical engineering students were asked to develop a system from initial idea to robust, functional solution: a mechatronic system. To carry out this project, not only did they need to apply what they had already learned in computer science, design, mechanics and materials science, but they also had to learn additional information. "We deliberately pull students out of their comfort zone," Meboldt says. Nevertheless the students plunge ahead with enthusiasm: calculating, designing, testing, scrapping.

Yet how is it possible to guide and support up to 500 students in one project? That's the job of the 30 coaches – students from more advanced semesters who lead the groups, helping them to work as a team and to bring the project to a successful conclusion. These more advanced students receive coaching training in a parallel course to help them in their task. As a result, their role in the Innovation Project equips them with the basics of management and coaching, which they can immediately apply in practice.

Professor Markus Meier laid the groundwork for the project-based teaching format in the Department of Mechanical and Process Engineering over 20 years ago. Since then, the basic idea has kept pace with the industry's rapid changes. His successor Roland Siegwart fleshed out the core concept of the innovation projects, and when Meboldt joined ETH Zurich in 2012, Siegwart handed over the course to his young colleague. Meboldt devoted himself to further developing the format, and it won the inaugural KITE Award in 2016.•

Prof. Dr. Mirko Meboldt

After several years in industry, Mirko Meboldt joined ETH Zurich in 2012 as Professor of Product Development and Engineering Design. His research focuses on the use of new technologies for the next generation of products and development processes.

Mixed reality delivers new insights

Mixed reality is becoming enormously popular in many different industries. Initial pilot projects show that the technology offers potential for education, too.

Real objects, such as furniture in a room, overlaid with virtual elements: mixed-reality headsets such as the HoloLens from Microsoft can create this illusion perfectly. Users can don the headsets and tour the resulting holograms, actually walking through them.

Initial pilot projects indicate that these headsets can broaden educationalhorizons, too. One example is the Computer-Assisted Drug Design course taught by ETH Professor Gisbert Schneider, who uses the HoloLens in a two-week block practical course. To develop a new medical drug, students have to find molecules that can interact with a certain protein. "This mean students have to be able to envisage the protein's surface, especially any indentations the molecules could fit into," explains co-instructor Jan Hiss. Obtaining this visual picture is no easy task. A protein's surface is defined by the position of the atoms it is composed of. The individual atoms have a van der Waals radius, which is specific to each atom. These radii produce a spherical model of the protein. "If you take, say, a water molecule and roll it over this spherical model of the protein, a new surface emerges. Its shape depends upon where the water molecule goes," is how Hiss explains the solvent-accessible surface area principle. To visualise this principle, he uses the HoloLens. As Hiss describes it, "The headset allows the students to essentially become the water molecule and immerse them-selves in the protein."•

Students using HoloLens mixed-reality headsets to study the surface of a molecule.

Prof. Dr. Gisbert Schneider

Since 2010, Gisbert Schneider has been Full Professor of Computer-Assisted Drug Design at the Institute of Pharmaceutical Sciences and has served as Associate Vice President for ETH Global since January 2018. His research focuses on the development and application of adaptive intelligent systems for molecular de novo design and drug discovery. His Computer-Assisted Drug Design course was one of three finalists for the 2016 KITE Award.

For innovations to take wing

The educational developers support teaching staff on all issues related to teaching, and coordinate developments within the degree courses. In their network, they take pains to ensure that teaching innovations find broad application across ETH Zurich.

ETH Zurich has a total of 11 educational developers who help the teaching staff to further develop and improve their teaching. At the same time, they make sure that innovative teaching ideas are not limited to any one department.

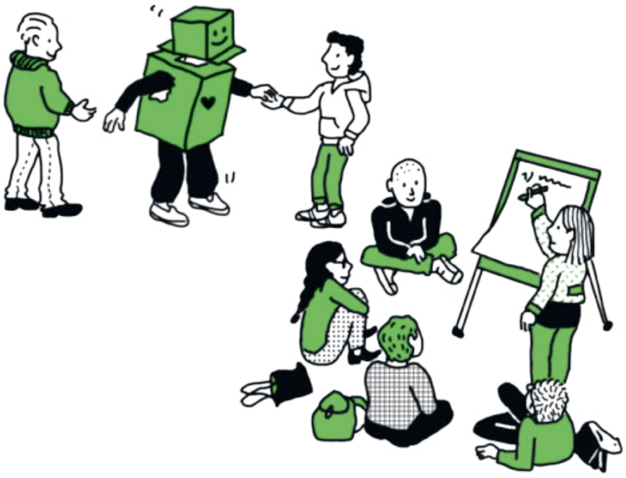
As an educational developer in the Department of Materials, Sara Morgenthaler works with professors, lecturers and students. She supports teaching staff in the didactic and methodological aspects of their roles, for instance when they want to use tools such as EduApp in their classrooms.

Morgenthaler places particular value on feedback from students. "I meet regularly with semester spokespersons from every year group. That's how I find out what their concerns are," she says. For example, students might point out to her overlaps in the content of certain courses, which she can then discuss with the lecturers involved. In addition, Morgenthaler regularly meets with students to discuss issues on the agendas of upcoming Teaching Services meetings. This official body makes suggestions for new course offerings or changes to programme regulations.

Morgenthaler gathers further information in meetings with other educational developers as well as with experts from the Educational Development and Technology administrative department (LET). At these meetings, the developers discuss new teaching methods and the current state of education development in the academic departments.

For instance, the mathematics department set up StudyCenters for the first time in Autumn Semester 2015. These are specific times during which teaching assistants help students go over the lecture material in more depth and solve problems together. Since then, this idea for supported learning has also been established in chemistry and biology, not least thanks to the network of educational developers.

Another teaching innovation is eSkript, or electronic script, which Morgenthaler and her network of colleagues have helped bring to a broader audience. eSkript is a tool that helps professors and lecturers develop interactive lecture materials as quickly and easily as possible. Ori-



ginally created for the Department of Health Sciences and Technology, professors and lecturers from a half-dozen other departments now use this tool.

"I meet regularly with semester spokespersons from every year group. That's how I find out what their concerns are."

In addition to her everyday tasks, Morgenthaler joins with Professor of Materials Theory and Director of Studies Nicola Spaldin to coordinate revisions to the materials science degree programmes. This area has made some major changes in the past decade: It is no longer divided into classes of materials – metal, ceramics, polymers – but focuses instead on common characteristics. So for example, there is a Professorship for Complex Materials and another for Multifunctional Materials. Morgenthaler says, "We want to better reflect this new organisation of the field at the Bachelor's level."

To design the new curriculum, Morgenthaler is involving professors, lecturers and students alike – as well as ETH alumni who now work for companies such as ABB, RUAG Space and Sonova. The idea is for these graduates to contribute their experience in industry to the realignment of the degree programme.

At the moment the new concept is under intense discussion, so the specifics are still up in the air. However, some initial ideas are already emerging. "For the first time, it will include engineering projects in which the students take apart, say, a ski or a lamp – and identify and work on materials science questions derived from the product," Morgenthaler says. •

Dr. Sara Morgenthaler

Sara Morgenthaler studied materials science at ETH Zurich and the University of Cambridge before earning her doctorate at the Laboratory for Surface Science and Technology in 2007. In addition, she has been head of the Competence Center for Materials Research, and then the Competence Center for Materials and Processes. Since 2015, she has been an educational developer in the Department of Materials.

Inspiring motivation: ETH Week

Manufacturing the Future: 180 ETH students from 16 departments worked on this topic together for one week. In interdisciplinary teams, they learned how the economy's production systems function.

ETH Week is a special event. To foster critical thinking and creativity in its students, ETH Zurich puts them into contact with professionals over the course of one week. The students are asked to identify the problem they want to solve – and not, as is so often the case, to carry out an assigned task. During ETH Week, students from all disciplines work together on real-life issues, with the support of science, industry and social experts from inside and outside ETH. At the same time, they learn to communicate with a wide range of people.

The topic for ETH Week 2017 was Manufacturing the Future. It focused on challenging today's and tomorrow's production methods and their effects on society, and developing ideas for improvement: How can we make effective practical use of the new opportunities digital factories offer? How should we design collaboration between humans and machines? And not least, how do we manage materials and resources? These were the questions students were mulling over last autumn on the Hönggerberg campus.

The organisers designed a comprehensive programme to help the participants familiarise themselves with the information necessary for this task. Project work was interspersed with field trips to companies plus lectures and discussions with experts. Topics ranged from engineering and the natural sciences to social sciences and the humanities, including fields such as politics and psychology. One goal of the project was to bring the students into contact with actual real-world requirements.

"The approach of this year's ETH Week – to rigorously relate production technologies to people and place them in a wider social context – is probably unique in the Swiss education landscape," says co-organiser Stefano Brusoni, Professor of Technology and Innovation Management. Feedback from the participating students was positive: they said the week was inspiring, the cooperative group work motivating; they tried out new ways of learning, as people from various disciplines developed ideas and created something new together.

ETH Week, which always runs for six days, is part of the university's Critical Thinking Initiative. It provides participants with the tools they need to tackle complex problems using an interdisciplinary approach. The event's focus is on cultivating institutional diversity, the exchange of ideas across disciplinary boundaries, critical thinking followed by self-critical reflection, and independent, responsible action.

ETH Week is made possible by the Avina Stiftung. As part of its commitment to learning, this foundation supports new approaches in education, training and the promotion of corporate action. 2017 was the third year ETH Week has been held. In 2016 the theme was Challenging Water, and in 2015 it was The Story of Food. The fourth ETH Week will be held in autumn 2018 with the theme of Energy. This year, the project reached the final round of the KITE Award (see p. 14).•

ETH Week brings students into contact
with business and political experts.

Learning the vagaries of autonomous driving with rubber duckies

The Duckietown educational project connects students at ETH Zurich with their peers from Montreal and Chicago. Together they operate a fleet of small autonomous vehicles – in the process solving problems that developers around the world grapple with as they work on self-driving cars.

The Duckietown educational project connects students at ETH Zurich with their peers from Montreal and Chicago. Together they operate a fleet of small autonomous vehicles – in the process solving problems that developers around the world grapple with as they work on self-driving cars.Small robots wend their way along streets marked out with tape. Perched atop the robots are rubber duckies – emblems of what have been dubbed "Duckiebots". The moving robots brake when they encounter a traffic jam, and stop at intersections to allow others to proceed.

What looks like child's play actually requires highly complex systems to harmonise hardware components, sensors and motors. Each semester of the course is devoted to one aspect of that interplay. All the groups consist of students from three universities: besides ETH Zurich, the other Duckietown project participants are the Université de Montréal and the Toyota Technological Institute at Chicago. "We place great value on making the course a shared experience," says Andrea Censi, senior assistant in Professor Emilio Frazzoli's research group in the Department of Mechanical and Process Engineering. Instead of only studying for tests, students are asked to solve problems as teams.

The biggest challenges in doing so are often of a practical rather than a theoretical nature. Components don't fit together properly, or the sunlight streams in at the wrong angle, threatening to throw the robots off course. "Things don't work the way the textbooks say they should. There are no perfect systems in robotics, and this is where our students learn how to cope with that," Censi says.

The solutions the students develop are readily available and the code that controls the vehicles with their rubber duckie pilots is open source, so anyone around the world can benefit from this pioneering work. The students benefit, too: by showing that they can successfully complete the group project under time pressure, they reach their learning goal – while at the same time acquiring a skill that is in high demand in industry.•

Students teaching "Duckiebots" autonomous driving.

Prof. Dr. Emilio Frazzoli

Emilio Frazzoli is Professor of Dynamic Systems and Control. He is an expert in the areas of control, distributed systems and algorithmic robotics. His research findings in the field of smart urban mobility have attracted huge interest worldwide. Previously, he was a professor at the Massachusetts Institute of Technology (MIT).

Learning spaces that bring ideas to life

One hundred years ago, students attended lectures at which the professor took centre stage. For books, they went to the library. "Today, increased mobility and digitalisation are making knowledge less centralised," says Christian Feghali, a real estate portfolio manager at ETH Zurich. In contrast to days gone by, professors are taking on more of a coordinating role as they guide students to key questions.

Even the rooms at ETH Zurich are adapting to these changes. Naturally there will still be auditoriums, especially for the large lectures for introductory courses. But at the same time there is a clear trend towards more open and more flexible learning spaces. "Larger spaces with more zones: places to meet and have discussions, and quieter areas for concentrated work," Feghali says.

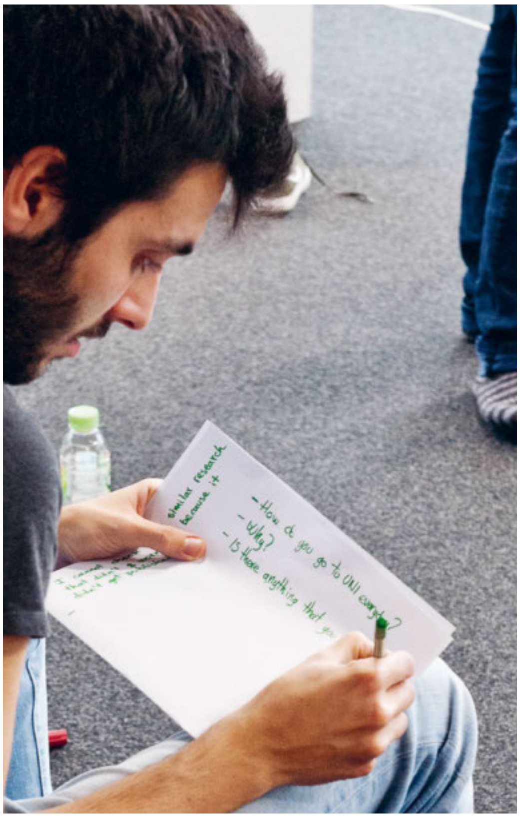
An example of this transformation is the Student Project House – a creative interactive space and workshop where students can bring their own ideas to life.

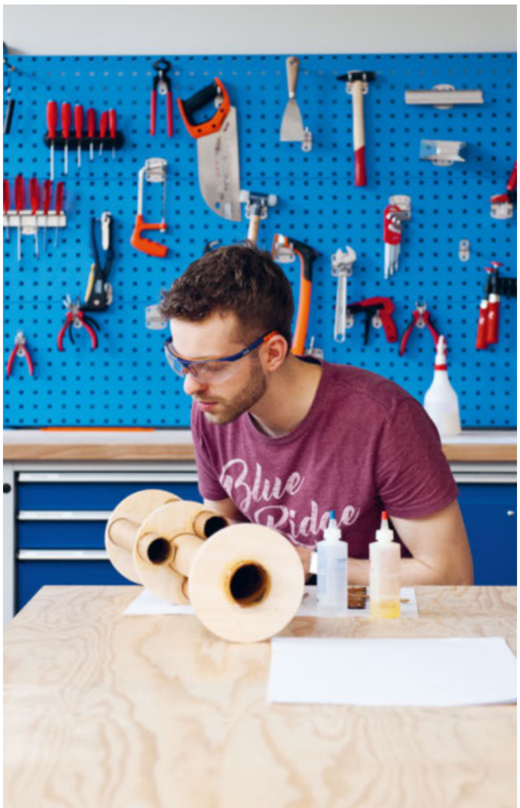
ETH Zurich has been running a pilot project on the Hönggerberg campus for the last two years.

This is what the Student Project House might one day look like on the inside (visualisation).

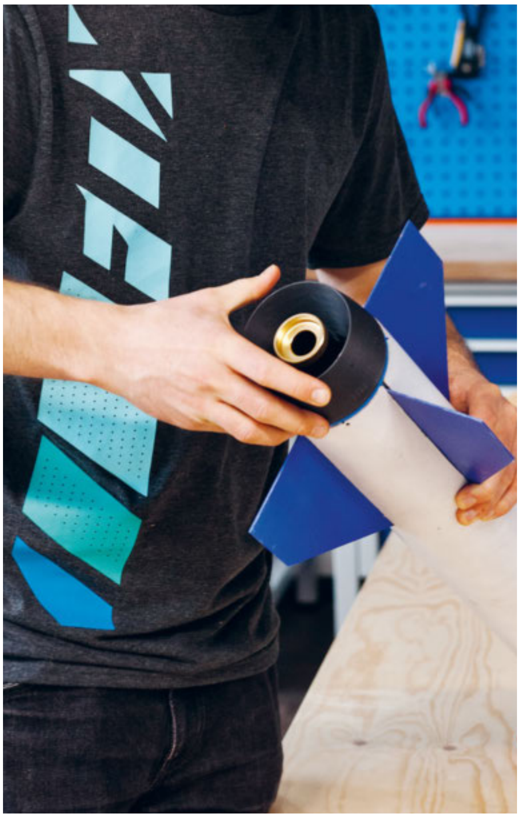
The Student Project House pilot

At the Student Project House pilot location, students are already drafting new projects.





In the Student Project House's Maker Space workshop, they build models and prototypes.



Support educational initiatives at ETH

Various projects were made possible by donations from foundations and private individuals, among them the Avina Stiftung and the Emil Halter Fonds. Here we present two projects that took shape thanks to the commitment of Adrian Weiss and the Adrian Weiss Stiftung.

You, too, can support innovative educational projects at ETH and help to advance teaching at the university. ETH teaching staff regularly submit new project ideas and seek financial support to make them a reality. For information on projects and funding opportunities, please contact:

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Project: MINTechnik-Akademie 10+

Project management Prof. Dr. Elsbeth Stern **Seed capital** CHF 35 000
Project status in preparation

For many years, ETH Zurich has helped to optimise primary, secondary and grammar school instruction in STEM subjects – science, technology, engineering and mathematics – known in German as MINT subjects. The Swiss MINT study (SMS) examines what impact classes based on the latest insights into teaching and educational research have on the learning and mental development of primary school students. As part of the study, some 6,000 children in 300 primary school classes receive age-appropriate instruction in physics. In the project, supported by Adrian Weiss, the focus is on finding children who scored particularly well on the SMS study test. They will have the opportunity to participate in special learning units, where they will work directly with pedagogically trained scientists to learn, for example, what makes bridges stable. Content on materials and health sciences is planned as well.

Further funds would make it possible to expand the SMS study. Currently, the focus is on 8- to 10-year-olds, but there is no follow-up solution for children aged 11 to 13. However, studies have shown that it is precisely in this age bracket that many girls turn to linguistic interests, even if they have top qualifications for STEM subjects.•

Project: Learning with HoloLens

Project management Thomas Korner **Seed capital** CHF 50 000
Project status pilot phase

Many experts see mixed reality as the next big thing. Last year, Microsoft launched the HoloLens, which enables a comprehensive range of mixed-reality applications. It certainly holds potential for use in the classroom.

ETH wants to run pilot projects to examine what opportunities HoloLens opens up for education. Twelve such headsets have already been purchased, and the university is now seeking funds to support the programming of applications with which the devices can be used in teaching. The Educational Development and Technology administrative department supports the projects.•

Interview with Adrian Weiss

"I want to inject momentum into education"

Mr Weiss, you have supported innovative teaching projects at ETH for several years. What motivates you?

I studied architecture at ETH, and have benefited from that outstanding education my entire life. Now I want to give something back to ETH and to the scientific community in general. I want to inject momentum into research and education, and foster appropriate plans and pilot projects in the most direct and unbureaucratic way possible. That's why I established a foundation that can dispense funds to Swiss universities and universities of applied sciences. The focus is primarily on ETH projects.

How do you ensure that the processes are as unbureaucratic as possible?

One example is the Rector's Impulse Fund, which we founded together with Rector Sarah M. Springman. The Rector has full freedom to submit proposals, and we then decide together which projects to finance. In addition, every year we run several interesting research projects in coordination with the ETH Zurich Foundation.

Which projects do you support? Or to put it another way, what criteria do you use to choose projects?

We focus on areas that could be crucial to our future, namely architecture, electrical engineering and computer science. Architecture, because that's what I studied. Electrical engineering, because I worked for many years in the family companies my father built up. And computer science, because it's a fascinating subject and one of my hobbies.•

ETH alumnus Adrian Weiss is the founder and president of the board of trustees of the Adrian Weiss Stiftung.

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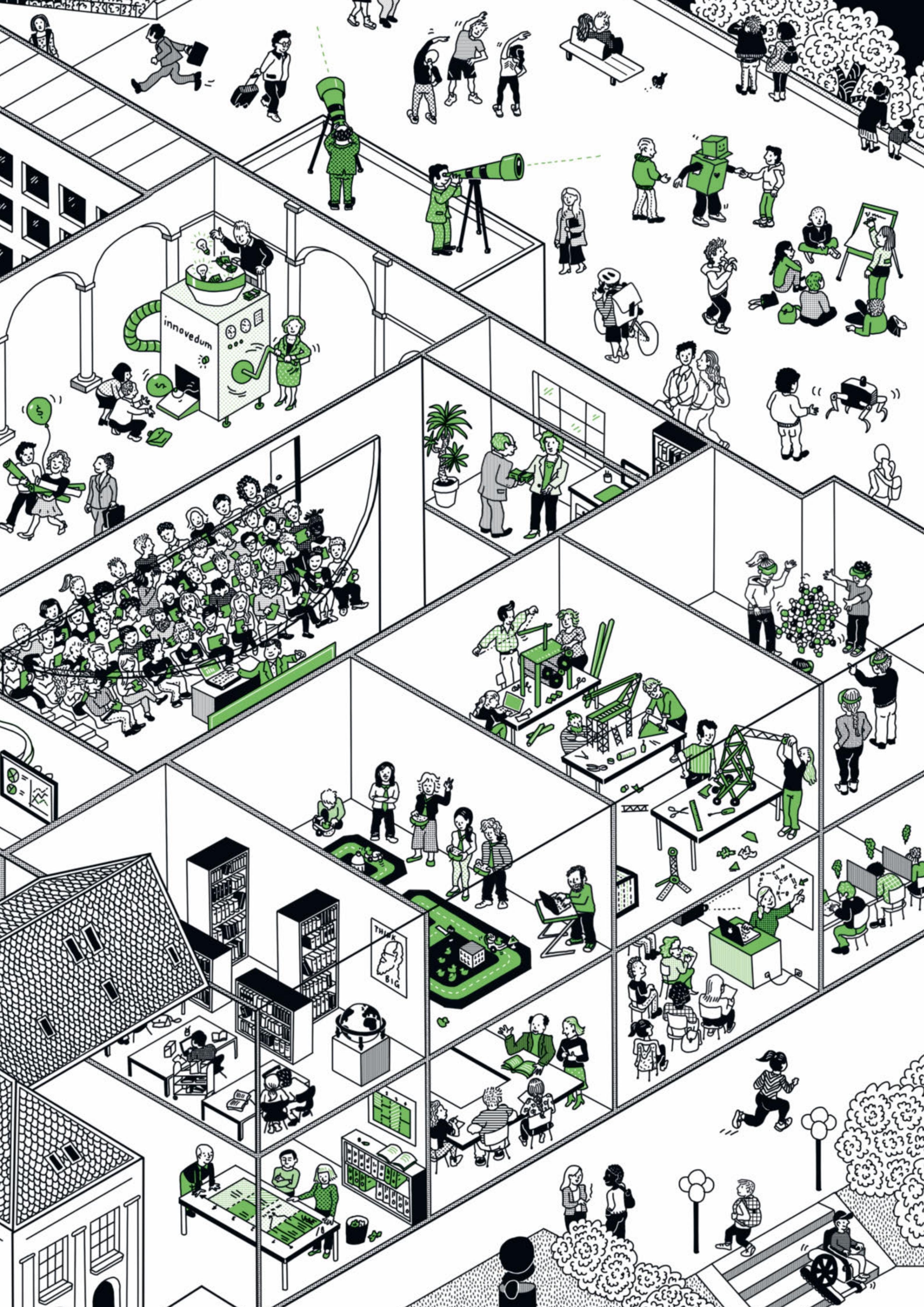
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ETH Zürich, April 2018