ATLAS UNIVERSITY COLLEGE TWENTE: A NOVEL APPROACH IN INTERDISCIPLINARY ENGINEERING EDUCATION

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Conference Key Areas: *Interdisciplinary education, Niche & Novel*
Keywords: *Engineering education, interdisciplinarity, New Engineer, self-directed learning*

ABSTRACT

ATLAS University College Twente offers a residential, interdisciplinary engineering program that aims at educating the 'New Engineer.' The program has embraced the concept of self-directed learning, meaning that students attain most of the program's learning goals in their own way. ATLAS is organized in semesters, each with their own specific learning goals. These so-called semester goals define a framework that allows students to build their own academic profile as New Engineers and, at the same time, safeguards that all students reach the intended learning outcomes of the program itself. One of the core values of the program is *integration*. Students follow mandatory courses in the domains of mathematics, natural - and social sciences, and work in interdisciplinary projects. ATLAS also offers interdisciplinary electives, designed and executed by teachers with different disciplinary backgrounds. Moreover, students are encouraged to use their extensive elective space to further build up their interdisciplinary profile as New Engineers. The program was successfully accredited in 2018 and is in a continuous state of development and innovation. This contribution discusses the set-up of the curriculum, its interdisciplinary components, its radical educational approach, assessment method, and future program developments and challenges.

1 INTRODUCTION

1.1 Kick - off

The academic year 2013 – 2014 marked the start of ATLAS, a Bachelor of Science degree program in Technology and Liberal Arts & Sciences. Twenty-six first-year students started their Freshman project in which they set out to bust an urban myth, for example: "Is a garden trampoline really a viable alternative to a Browder life net?" Discovery Channel's *Mythbuster* Jamie Hyneman introduced the students to their first project via a video link. Two years before, founders of the program Kees Ruijter and Jennifer Herek visited different faculties and departments of the University of Twente (UT) in search for members of what would form the core team of ATLAS.

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This team laid the groundwork for the program and began executing it. The ATLAS core team is still in place, including teacher members that were there from the beginning and new members, all with various academic backgrounds and nationalities.

1.2 The need for New Engineers

Innovation in engineering education has been the subject of heated discussions over the past 20 years (Kamp, 2016). It is thought that the combination of technology being a dominant force in society and the challenges the world is facing today should have consequences for the way we educate engineers. Today's breakthrough technologies seem to cross traditional disciplinary boundaries, implicating modern engineering solutions require an integrated perspective, especially in the way technologies are introduced into and affect society (see e.g. Bammer, 2013). They require a new kind of engineer (Goldberg, Somerville & Whitney, 2014).
Since the sixties, the UT has had a pioneering mindset in engineering education. Inspired by the Liberal Arts & Sciences programs of the Dutch University Colleges and the educational practice of new engineering programs worldwide, like Olin College of Engineering (Needham, Massachusetts), the UT launched ATLAS, an engineering program for New Engineers.

1.3 The ATLAS vision on the New Engineer

The core team that developed ATLAS created a visionary profile of the New Engineer containing five core values that stipulate how ATLAS Engineers are different from engineers educated in more traditional programs (UCT, 2018). These values concern *integration, trailblazing, community, self-directedness and excellence.* The profile describes that ATLAS engineers are equipped to solve challenges of our time that require the integration of perspectives from a wide variety of fields. Trailblazing their way, they dare to take a step into the unknown, pursue radically new solutions, take the initiative, while being open to innovation, creativity and novelty. They approach the world as a community and create and research with that community and for that community. ATLAS engineers are agile, have an open, independent and critical attitude, and are life-long self-directed learners. They strive for excellence; they have an urge to improve themselves and the ability to focus and persist on a topic or skill to reach and utilize their full potential.
This profile, in combination with the academic criteria for bachelor and master curricula (Meijers, van Overveld, & Perrenet, 2003) and the Domain Specific Frame of Reference (DSFR) that was developed for Liberal Arts & Sciences programs in the Netherlands, shaped the Intended Learning Outcomes of the program. The DSFR framework, based on more than 15 years of experience with Liberal Arts & Sciences education in the Netherlands, is aligned with European and international Liberal Arts & Sciences networks, assuring the connection with the expectations and requirements of the international educational field (UCT, 2018).

2 SET-UP OF THE CURRICULUM

2.1 Semester structure

The set-up of the ATLAS curriculum is straightforward with only two components: semesters and Personal Pursuits. Semesters have a study load of 27 credits and Personal Pursuits bear 6 credits. Each year contains two semesters and one Personal Pursuit.
Semesters are the main building blocks of the curriculum. Each semester has semester goals that, across all semesters, build up to the Intended Learning Outcomes of the program. All students need to reach these semester goals. Semesters one through four have the same set up: each contains a project, courses in different academic domains (natural sciences, social science and mathematics) and room for electives (starting in semester 2). The projects and domain courses are organized by ATLAS and followed by all students. Semester five is the semester "beyond ATLAS". Students then only take courses outside of ATLAS at another faculty of the UT or another (national or international) university. Semester six is the final semester. It is a signature semester with a Capstone project and elective courses that students attune to their own academic profile as a New Engineer. The elective space gradually increases throughout the program. At the minimum, students spent one-third of the program on electives.
Taking electives is not a goal in itself, it is a means to reach certain semester goals. For example, one of the semester goals in semester 3 states that students "*Demonstrate deepening of academic competencies in domains or fields that are relevant to their intended profile as a new engineer.*" It is clear that this goal can be met in different ways, depending on the direction students are taking. Electives then are a means to demonstrate deepening of academic competency in domains or fields that are relevant to them. It is in the way this type of semester goals is reached that the program becomes personalized, allowing students to create their own profile as a New Engineer. At the start of each semester, students present a plan on how they intend to reach the semester goals. The program sees to it that these plans meet appropriate academic standards (see paragraph 4).

2.2 The Personal Pursuit

The Personal Pursuit encourages students to turn their personal interests into an integral part of their academic development and is a unique Liberal Arts & Sciences part of the ATLAS program. Each year, students work on a project (6 credits, which equals 168 hours of work) that fully stems from a personal interest; something they have always been interested in doing, investigating, or designing. Students write a proposal describing their goals, planned activities, outreach to the community, and intended evidence to prove that they met their goals. The Personal Pursuit proposals are assessed by a special committee, safeguarding the academic level of the pursuit. Students have been working on subjects like synesthesia and forensics, photography, fiction writing, learning a new language, composing music, clothing design, motorcycle repair, and woodworking for their Personal Pursuit projects.

3 INTERDISCIPLINARY COMPONENTS

One of the core values of the New Engineer is *integration*, which relates to the ability to function as the linking pin in a team of experts with different disciplinary backgrounds and be able to cross disciplinary boundaries in solving complex problems. In different ways, the ATLAS program lives up to this value.

3.1 ATLAS admission procedure

Obviously, incoming students know what they are up to. Information available for them clearly explains what the program is about and during Open Days, Student-for-a-days and so-called In_Sight Days, prospective students learn about and experience the aims of the program. As part of the admission procedure, interested students are interviewed by both teachers and ATLAS students. An important topic of the interview is to learn about the students' interest in different academic disciplines and their vision on what is needed to solve the grand challenges of the world as New Engineers.
During the In_Sight Days, prospective students collaborate on preparing a mitigation plan to solve a complex problem (e.g. how to prevent temperature rise in big cities or mitigate the adverse effects of sinking cities like Jakarta). Based on this experience, they reflect on working on this type of collaborative projects. ATLAS teachers observe the collaboration process and give feedback on the proposed mitigation plan.
The students' reflections, the teachers' observations and the interviews are, amongst other things (school performance record, motivation letter, student resume) input for the decision of the admission committee. In this way, ATLAS aims to admit students who already have a certain affinity with integrating different disciplinary perspectives in an engineering context.

3.2 ATLAS domain courses and modelling

In the first and second year of the program, ATLAS students develop literacy in three domains: natural science, social science and mathematics. They follow mandatory courses in these domains, developed by the ATLAS core team of teachers. On the one hand, the contents of the courses are aligned with requirements for existing master programs, on the other hand teachers in these courses collaborate in creating a learning experience that supports integration. One example of this, is the focus on *modelling*. In the first semester, modelling is introduced as an aspect integral to all academic disciplines. Using modelling as a framework, students discover how experts from different domains try to understand real-world phenomena. It is thought that this fosters their ability to integrate. For an example of the use of modelling across domains in education, see English (2009). Eisenbart, Gericke and Blessing (2017) have advocated to use modelling in the interdisciplinary design process.

3.3 ATLAS interdisciplinary projects

In the first four semesters, students work on projects in groups. The nature of the projects becomes increasingly complex in the sense that the challenge they work on becomes more extensive and the number of stakeholders involved grows. For example, students in semester one might work on developing a new type of walking bridge for children with cerebral palsy, while students in semester four work on a

plan to mitigate the effects of extreme famine in Southern Africa. In the projects of semester two and four, students contribute from a personal interest (semester two) and from their own developed expertise (semester four). This is another way to scaffold the need to integrate. In the students' Capstone project (their bachelor thesis), students are further encouraged to develop their integrative ability. To support this, ATLAS encourages students to choose supervisors with different disciplinary backgrounds.

3.4 ATLAS integrative electives

A recent development, inspired by our colleagues from Olin College (Needham, Massachusetts), is the development of ATLAS integrative electives. The idea behind these electives is that teachers with different disciplinary backgrounds teach about a subject which links the disciplines. One ATLAS teacher in physics and one in social science developed a course with the elusive name "Sensors and Sensibility" in which they focused on the use of physical sensors (e.g. blood pressure sensors or galvanic skin response sensors) for studying mental states (e.g. fear or arousal). The course focuses on how the sensors work, but also on how social scientists use sensor data to measure certain mental states. Studying the reliability and validity of these measures calls upon the ability to integrate knowledge and insights from both disciplines. Of course, developing the course also helped the teachers to become more informed on each other's discipline, fostering their interdisciplinary abilities.

3.5 Creating their own profile as a New Engineer

In different ways, ATLAS stimulates students to work on their integrative abilities. From the admission on, ATLAS wants students to become New Engineers. Therefore, it is expected that students use their extensive elective space to pick courses from different academic disciplines. To safeguard that the choices they make are not random, ATLAS offers a developmental framework which scaffolds the build-up of their own interdisciplinary profile as New Engineers. This system is explained in the next section.

4 RADICAL EDUCATIONAL APPROACH

ATLAS has adopted the concept of self-directed learning (Gibbons, 2002; Pintrich & Zusho, 2002; Saks & Leijen, 2014). Each semester sets a developmental framework with semester goals that safeguards that each student can reach the Intended Learning Outcomes of the program. However, the semester goals can be attained in different ways, depending on the interest of the student. Other program requirements, for example doing the interdisciplinary projects in semester one till four, are also part of the framework. Self-directedness in the program (another core value of the New Engineer) concerns making curricular choices and taking responsibility for your own learning. At the start of each semester, students reflect on their interests and direction and make curricular choices to pursue those interests, within the boundaries of the developmental framework. The choices they make culminate in a plan (a Personal Development Plan; PDP) that needs approval. In the plan, the students also explain how they will prove they met the semester goals. To this end, they propose certain evidence (defined as student work combined with expert feedback) that shows they met the goals. The fact that, to a large extent,

students can attain the semester goals in their own way, gives them the opportunity to create their own interdisciplinary profile as a New Engineer.

5 ASSESSMENT METHOD

The concept of self-directed learning does not fit easily within the frameworks and indicators used for quality assurance in higher education in the Netherlands. The Dutch Higher Education Act (Dutch Government, 2020) is implicitly geared towards a model of prescribed courses that are uniformly assessed and, together with a thesis, make up a curriculum. In this model, quality assurance relies heavily on guarding the quality of assessment as carried out by the teachers. ATLAS has, for a large part, made students responsible for the design of their assessment plan. The challenge for ATLAS is to find a way to assure and account for the quality of assessment in such a way that it still affords self-directedness, meaning allowing students to make their own curricular choices to build up a unique profile as a New Engineer.
ATLAS its solution for this challenge lies in the so-called “PDP-MTE-SER” cycle. As said, the PDP contains the students’ curricular choices, including an assessment plan. In a Midterm Evaluation (MTE) halfway the semester and the Self Evaluation Report (SER) they produce at the end of the semester, students reflect and evaluate to what extent they have reached the semester goals. Assessment of students is based on whether their self-evaluation can be justified. Because the choices students can make to reach their goals are diverse, ATLAS needs to continuously monitor and calibrate these in order to safeguard the quality of education and assessment.

This is what students say about the ATLAS approach:

“Even though we have always had all the freedom to set out our own path, we have always been perfectly aware that not every hodgepodge of course selections will lead to a perfectly balanced multidisciplinary profile. Students know they have to connect every course of interest to an idea of how it adds to their academic profile – and the structures that have been put in place to ensure this are greatly valued by your students (UCT, 2018).”

The program was successfully accredited in 2018. To show that the program achieved its learning outcomes, the assessment of the capstone projects was taken as an indicator. Of the 60 capstone projects that had been assessed up until then, 63% were rated as very good or excellent, 25% as good and 12% as sufficient. These assessments were done by external supervisors, indicating that the program is successful at educating students to a Bachelor of Science level. Another indicator related to entrance to master’s programs. Of the 60 graduates that were tracked for the accreditation, 65% had started the master of their choice directly, while 5% required some form of bridging course before they could start their master (30% took a gap year, for reasons ranging from entering engineering competitions, work, board work or travel). Of the graduates that entered a master either directly or after a gap year, 94% were admitted directly into the master of their choice. The universities they were admitted to include prestigious universities like ETH, Imperial College London, University of Edinburgh, and University College London. The master programs range from purely natural science (e.g. Quantum Physics at University of

Copenhagen), to mathematics (e.g. Machine Learning at Aalto University), to classical engineering (e.g. Micro & Nano Systems at ETH), to new engineering (e.g. Sustainable Development at Universities of Graz & Venice), to social science (e.g. International Relations & World History at the University of Nottingham in China). This was considered proof that the program is successful in educating students to a Bachelor of Science level in their chosen academic profile while maintaining the Technology and Liberal Arts profile.

6 FUTURE PROGRAM DEVELOPMENTS AND CHALLENGES

The ATLAS program is still “engineering its education.” Not only because of the radical new approach that is constantly put to the test while the shop is open, but also because the core team of teachers are becoming experts in interdisciplinary education more and more, and therefore keep developing better ideas on what New Engineers need and how to deliver that. To conclude this paper, we want to address the main areas of development and some challenges the ATLAS core team is facing.
First, the core team members realize that to be able to deliver interdisciplinary education, they have to become more interdisciplinary themselves. The importance of collaboration and integration obviously applies just as well to them as to the New Engineers they educate. While several core team members work in the program part-time and the execution of the program is time-consuming, team development is relatively slow in this respect. Currently, new core team members are being appointed which will hopefully speed up this development
Second, ATLAS wants to grow, but needs to think about how a higher influx will affect the quality of education (ATLAS currently has an influx of approx. 50 students per year). For their own courses, ATLAS teachers provide extensive feedback, which is time-consuming. Also, student-teacher learning interactions are highly frequent, both inside and outside the classroom. While this affects learning positively (see e.g. Hattie, 2092) and is highly appreciated by students and teachers alike, upholding these dynamics when more and more students enter as first-years will be a challenge.
Thirdly, now ATLAS is in its second lustrum and was successfully accredited in 2018, the core team of ATLAS has become more aware of the privilege given to them by the UT to independently develop a program that is unique in many aspects. Despite the challenges described earlier, ATLAS also wants to start sharing its educational experiences with the engineering education community and invest in educational research so that ATLAS does not become a well-hidden secret, but a driver for further development of engineering education.

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