

Evaluation report

Vrije Universiteit Brussel – Faculty of Engineering
VUB

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For your information:

*The CTI evaluation reports are written in unjustified layout, in order to facilitate the reading for people suffering from dyslexia.

Name of the institution: Vrije Universiteit Brussel - Faculty of Engineering
 Acronym: VUB
 Country: Belgium
 Institution's head office: Brussels

CTI accreditation application, campaign: 2021-2022
“Admission par l’Etat” and EUR-ACE® Label

I. Scope of the evaluation procedure

Following bachelor’s programmes have been evaluated but are not eligible for admission by the French state or for the EUR-ACE® label:

Application category	Programme	Pathway
Bachelor’s	Bachelor of Science in Engineering	Initial engineering training under student status
Bachelor’s	Bachelor of Science in Engineering: Architecture	Initial engineering training under student status

Accreditation application of the institution for the renewal of the admission by the French state and the EUR-ACE® Label for the following programmes:

Application category	Programme	Pathway
Renewal Admission par l’Etat (RAD)	Master of Science in Electromechanical Engineering <i>(Joint programme with Université Libre de Bruxelles)</i>	Initial engineering training under student status
Renewal Admission par l’Etat (RAD)	Master of Science in Chemical and Materials Engineering <i>(Joint programme with Université Libre de Bruxelles)</i>	Initial engineering training under student status
Renewal Admission par l’Etat (RAD)	Master of Science in Civil Engineering <i>(Joint programme with Université Libre de Bruxelles)</i>	Initial engineering training under student status
Renewal Admission par l’Etat (RAD)	Master of Science in Architectural Engineering <i>(Joint programme with Université Libre de Bruxelles)</i>	Initial engineering training under student status
Renewal Admission par l’Etat (RAD)	Master of Science in Electrical Engineering <i>(Joint programme with Université Libre de Bruxelles)</i>	Initial engineering training under student status
Renewal Admission par l’Etat (RAD)	Master of Science in Applied Sciences and Engineering: Applied Computer Science	Initial engineering training under student status
Renewal Admission par l’Etat (RAD)	Master of Science in Photonics Engineering <i>(Joint programme with Ghent University)</i>	Initial engineering training under student status
Renewal Admission par l’Etat (RAD)	Master of Science in Biomedical Engineering <i>(Joint programme with Ghent University, evaluated at Ghent University, refer to the UGent evaluation report)</i>	Initial engineering training under student status

Accreditation application of the institution for the EUR-ACE® label for the following programmes, which are not eligible for admission by the French state:

Application category	Programme	Pathway
REU (renewal EUR-ACE® label)	European Master of Science in Photonics <i>(Joint programme with Ghent University)</i>	Initial engineering training under student status
REU (renewal EUR-ACE® label)	Advanced Master of Science in Nuclear Engineering <i>(Joint programme with Ghent University and KULeuven, evaluated at KULeuven, refer to the KULeuven evaluation report)</i>	Initial engineering training under student status

II. Presentation of the faculty

The engineering faculties of three Flemish universities (VUB, UGent, KU Leuven) applied for the renewal of a CTI evaluation with the aim to have their master's programmes recognised in France via the "Admission par l'Etat" procedure and at the European level through the EUR-ACE® label. These master's degrees are awarded after the completion of a 5-year programme involving a 3-year general science and technology undergraduate degree (bachelor's), followed by a 2-year specialisation resulting in a master's degree. The first cycle ends with the award of a "transitional" bachelor's degree.

General description of the faculty

VUB is the Dutch-speaking offshoot of the French-speaking Université libre de Bruxelles (ULB), founded in 1834 by Théodore Verhaegen. Although some law courses were already being taught in Dutch in 1890, it was not until 1963 that almost all the faculties offered courses in Dutch. Following a political crisis, VUB split off from ULB on 1 October 1969 and officially became a separate legal, administrative and scientific entity in May 1970.

The Faculty of Engineering (FIRW) is one of the eight faculties of the Vrije Universiteit Brussel (VUB). Both the mission and the strategy of the faculty are aligned with those of the VUB. In 2022, 1 636 students were enrolled in the FIRW, 397 have graduated including 188 from joint BRUFACE programmes.

The university operates as an autonomous and democratically governed institution based on the principle of free inquiry. The Organizational Statute describes the mission of the university and its policy, governance and administrative bodies including their respective responsibilities.

The mission of the university includes:

- Developing, transferring and applying a high-quality academic education and scientific research, free from any form of preconception;
- Integrating these endeavours with a spirit of social concern;
- Developing critical thinking amongst staff and students as part of their responsibility to society;
- Transferring knowledge to the social and economic sectors in view of strengthening their innovation capacities.

The mission of the Faculty of Engineering states that "The faculty produces critical engineers that are key to our knowledge-intensive and driven society and that support the development of the high-tech economic landscape. The faculty creates levers to ensure welfare in a sustainable way".

According to the faculty's self-evaluation report (SER), in 2021, the Faculty of Engineering had 562 bachelor's students and 531 master's students for a total of 1 169 students.

This evaluation report only applies to some programmes of the Faculty of Engineering:

- 2 bachelor's programmes (180 ECTS credits): BSc in Engineering (34 graduates in 2020) and the BSc in Engineering: Architecture (19 graduates in 2020). The language of instruction is Dutch;
- 7 master's programmes (120 ECTS credits each):
 - Master of Science in Electromechanical Engineering (94 graduates in 2020);
 - Master of Science in Chemical and Materials Engineering (29 graduates in 2020);
 - Master of Science in Civil Engineering (39 graduates in 2020);
 - Master of Science in Architectural Engineering (50 graduates in 2020);
 - Master of Science in Electrical Engineering (46 graduates in 2020);
 - Master of Science in Applied Sciences and Engineering: Applied Computer Science (20 graduates in 2020);
 - Master of Science in Photonics Engineering (34 graduates in 2020).
- 1 European master's programme (120 ECTS):
 - European Master of Science in Photonics.

The number of graduates for each programme indicated in this report is taken from the VUB international data sheet.

The 5 first master's programmes are taught in English in the frame of BRUFACE (Brussels Faculty of Engineering), which means they are jointly operated between VUB and ULB. As such, the results of the evaluation procedure of the BRUFACE programmes also concern ULB.

According to law in Flanders, these programmes are taught in English, provided that equivalent courses are also offered in Dutch.

The master's programme in photonics is operated jointly between VUB and UGent. Therefore, the results of the evaluation of this programme also concern UGent.

Like other faculties at VUB, the Faculty of Engineering manages its human and financial resources with a great degree of independence. It has eleven departments that are responsible for courses closely related to their scientific research.

A twelfth department, INDI (Industrial Engineering), is responsible for the bachelor's and master's programmes in Industrial Engineering (240 ECTS in total). The CTI evaluation did not cover this department.

Research is one of the pillars of the faculty: on average 11.4 publications and 323K€ acquired research budgets per year per professor. Department councils are responsible for the management of the departments. Education is a cross-disciplinary activity managed by the Faculty Education Committee (FOWC) and relies on the human resources and equipment provided by the departments. The Faculty of Engineering receives financial resources mainly from private research funding from companies that use the research results. The general policy of the Faculty of Engineering is to "develop, transfer and apply high-quality academic education and scientific research, free from any form of preconception".

Research-driven education is emphasised with a bottom-up approach to designing programmes. This approach is based on the expertise of research teams and provides the latest cutting-edge scientific knowledge.

Many spin-off companies are created from FIRW programmes: 21 of the 42 spin-offs developed through VUB TechTransfer are from the Faculty of Engineering.

Programmes

- The BRUFACE Master of Science in Electromechanical Engineering aims at educating interdisciplinary problem solvers with strong theoretical knowledge and in-depth specialisation in mechanics and electrotechnics. There are 5 graduation options: Robotics and Mechanical Construction, Sustainable Transportation and Automotive Engineering,

- Operation Engineering and Management (concerns only ULB), Energy, Aeronautics.
- The BRUFACE Master of Science in Chemical and Materials Engineering aims to educate engineers capable to address the modern technological needs of the labour market concerning process, chemical and environmental technology and material's science. 2 profiles can be chosen: Process Technology and Materials.
- The BRUFACE Master of Science in Civil Engineering aims at providing a broad and multidisciplinary science-based education in the design, building, and maintenance of civil engineering projects, with 3 pillars: Sustainability, Technological Society, Fascinating structures. In the second master's year students must choose between: Innovative design of civil engineering structures, Geotechnologies for sustainable developments, Reliability and monitoring in civil engineering.
- The BRUFACE Master of Science in Architectural Engineering is structured around 3 fields: Architectural Sciences, Engineering Sciences and Architectural Design, and aims at optimising the synergy between engineering and architecture.
- The BRUFACE Master of Science in Electrical Engineering provides in-depth theoretical knowledge in the possible applications of electronics and information technology. In the second year of the master's programme, 3 options are available: Nano-optoelectronics and embedded systems, Information and communication technology systems, Measuring modelling and control.
- The Master of Science in Applied Sciences and Engineering: Applied Computer Science offers a broad education in Data Science and Data Engineering. Minors of the first year include: Smart cities, Digital health, Digital earth.
- The Master of Science in Photonics Engineering is operated with UGent. It includes an on-campus learning track and a semi-digital model learning track; it includes a course on recent trends in photonics and has a high inflow of international students.
- The European Master of Science in Photonics is also coordinated jointly between VUB and UGENT.

Resources

The faculty staff totals 563.9 full time equivalent, of whom 153 staff members are employed on the working budget of the faculty and 411 on external resources (73%). Funds obtained through research projects also benefit education, since research and education are closely intertwined. The budget allocated to the faculty and devoted to education in 2021: 136,477€ from the faculty educational budget, 31,470€ from the Education Fund, 24,000€ for multimedia equipment, 373,469€ for large-scale specific equipment for 8 years (of the 1,845,000€ for the entire VUB education budget).

Changes to the institution

According to the recommendations of CTI, the faculty has evolved very positively, increasing its staff when necessary and broadening its quality assurance system. The measures taken due to the COVID sanitary crisis also generated progress in teaching, which strongly uses hybrid techniques. One of the master's programmes (Photonics Engineering) also took this opportunity to develop a partially online track.

The new strategic plan of the university (ASP4) is well aligned with the new challenges of education, and the strategic goals of FIRW match with ASP4 and with those of the future of engineering.

However, the level of recruitment of Belgian students with respect to foreign students is a point that still needs to be carefully monitored. This year in particular saw a 30% increase in first year bachelor's students.

III. Follow-up of previous CTI guidelines for improvement

For the **Faculty of Engineering** of Vrije Universiteit Brussel:

Previous guidelines for improvement CTI's decision recommendation n° 2016/09-12	Evaluation by the expert panel
The faculty would benefit from including engineering fellows and industry professionals in the teaching teams as much as possible.	Implemented
The panel regrets that the relatively basic indicators are not available in a public and synthetic form.	Under implementation
The BRUFACE experience as well as the alliance with NPU in China should be used to foster international partnerships with specifically chosen European universities.	Under implementation
The BRUFACE project should be used to attract more foreign students and create real joint programmes.	Implemented
Outbound student mobility is far from what could be expected from a university wishing to educate "world citizens": the faculty should take strong actions to reach the VUB target of 20% student mobility.	Under implementation
Inbound student mobility is low as well and the university could capitalise more on its key location in the middle of Europe.	Implemented
VUB lacks a strategic vision and has some problems projecting into the future. Planning actions must be undertaken in order to include architectural engineering topics in the priorities of the energy transition and the post-carbon civilization.	Implemented
Promotion of the BRUFACE deserves greater attention.	Under implementation
A lack of surveys on future needs is regretted. This would help anticipate updates to curriculum.	Implemented
Continuous improvement cycle (Deming Wheel) is a good way to efficiently complete any Quality Assurance system.	Under implementation
Well-structured organisation, Quality Assurance training, well-distributed responsibilities, few, well-chosen and relevant KPI and tracking, fully consistent with the Institution Strategy, will give meaning and associated measurable results.	Implemented
Participative methods still need to be worked on and Quality Assurance is a good way to develop them and measure the benefits. Results will be published naturally when KPI have been defined, accepted by all actors when the quality system is working and the first results obtained.	Implemented
Include more people in the quality process.	Implemented
Build a strategy policy for each master's programme.	Implemented
Build a real international policy, particularly for students and staff, both ways.	Under implementation
Include outside managers from Industry and other stakeholders in the different VUB decision-making committees.	Implemented
Organise a real win-win policy between alumni, students, graduates and the institution.	Under implementation

For the **bachelor's programmes** of the Faculty of Engineering Science of KU Leuven:

Previous guidelines for improvement CTI's decision recommendation n° 2016/09-12	Evaluation by the expert panel
Bachelor of Science in Engineering: Reduce student workload and dropout levels in BA1 and BA2 (BA Engineering).	Implemented
Bachelor of Science in Engineering: Architecture: Improve dialogue with other architecture programmes in Flanders (BSc Architectural Engineering).	Implemented
Bachelor of Science in Engineering: Architecture: Adapt infrastructure to teaching.	Implemented

For the **master's programmes** of the Faculty of Engineering of Vrije Universiteit Brussel:

Previous guidelines for improvement CTI's decision recommendation n° 2016/09-12	Evaluation by the expert panel
Master of Science in Electromechanical Engineering: Reduce the workload of students, encourage student and staff mobility.	Under implementation
Master of Science in Chemical and Materials Engineering: Establish a vision for the future, develop outbound mobility, clarify student recruitment strategy, increase teaching in process safety.	Implemented
Master of Science in Civil Engineering: Increase the number of internships, select your international partners.	Implemented
Master of Science in Architectural Engineering: Put internationalisation at the centre of staff concerns, develop relations with Sint Lucas.	Implemented
Master of Science in Electrical Engineering: Increase connections with industry and work on students' oral communication skills.	Implemented
Master of Science in Applied Sciences and Engineering: Applied Computer Science: Communication and visibility of the programme should improve.	Implemented
Master of Science in Applied Sciences and Engineering: Applied Computer Science: Ensure that each student has meaningful contacts with the business world.	Implemented
Master of Science in Applied Sciences and Engineering: Applied Computer Science: Involve professors and teachers more in the applicants' selection process and systematically interview all candidates.	Implemented
Master of Science in Applied Sciences and Engineering: Applied Computer Science: Include more courses to help develop transferable skills and career guidance.	Implemented
Master of Science in Applied Sciences and Engineering: Applied Computer Science: Organise regular discussions between alumni, students and faculty in order to stay informed of career changes and update the programme.	Implemented

Conclusion

VUB has done a great job to satisfy most of the guidelines for improvement. However, due to the COVID sanitary crisis, some of them, mostly concerning outbound internationalisation, have not been completely fulfilled.

Concerning quality assurance, this notion has spread much more than previously.

Although BRUFACE programmes have progressed in management, there are still some challenges to be overcome concerning common data tools and management.

IV. Description, analysis and evaluation by the expert panel

Mission and organisation

VUB is a Flemish University that is very unique due to its location in international and European Brussels where most of the population is French speaking, and due to its small size allowing for teaching in small groups where trust between students and teachers really exists. It also remains strongly supported by research like all other Flemish universities and has therefore had to define a strategy of successful alliances to welcome a high percentage of foreign students. All these characteristics must be taken into consideration to better understand its strategy.

The mission of the Faculty of Engineering is to train critical engineers that are keys to a knowledge society, supporting the development of the high-tech economic landscape. Its role is to create leverages to ensure welfare in a sustainable way.

The university has defined a new strategic plan (ASP4) keeping the same 4 strategic measures and 10 strategic goals as previously but has added complementary goals:

- Improving governance, leadership, infrastructure and people in view of managing growth without losing quality and identity, which in some programmes is defined as “smart growing”;
- Building further on a research-driven educational institute;
- Setting course to Horizon Europe whilst remaining firmly anchored in multicultural Brussels and Europe, promoting the international orientation.

In the context of the faculty, the strategic goals are:

- The VUB engineer is a strong Flemish and international brand;
- The VUB engineer is prepared for industry, economy and society;
- Multidisciplinary, sustainability and diversity are embedded in the genes of a VUB engineer;
- A robust faculty is needed.

Some of these goals were clearly observed during the evaluation procedure, while for others, the team thinks that until now, there has only been a tendency (such as the desire for interdisciplinary education), perhaps due to the COVID pandemic.

The faculty has classified its objectives according to their time-related priorities:

1. OG1 Recruitment
2. OG2 Evolution of programmes
3. OG3 Follow-up of CTI guidelines for improvement
4. OG4 Integrate industrial engineers
5. OG5 Open an English taught Bachelor's programme
6. OG6 Improve faculty services (2024-2027)

Considering the limited number of human resources, it is a reasonable strategy that fits well with the weaknesses observed during the evaluation procedure.

The BRUFACE programmes, taught in English between ULB and VUB, is a clear answer given the need for internationalisation and diversity. It also allows the universities to cope with a lack of human resources. It concerns 5 main engineering programmes. These BRUFACE programmes are better known than 6 years ago, but efforts still need to be made when it comes to internal communication, platforms used for students, and data storage.

Joint programmes with other Flemish universities are also successful with the same need for clarification of data and platforms. However, these organisations have already made improvements, especially for the registration of students.

Each programme has a three-year strategic plan and students in the programme committees are very involved and their opinions are taken into account.

Furthermore, the BSc in Industrial Sciences (Engineering Technology) is still attracting some specific categories of students and bridges exist to some degree, so that, for example, students who are unsuccessful in the BSc in Engineering can continue in the BSc in Industrial Sciences, or BSc in Industrial Engineering graduates can enrol in a MSc in Engineering. The remediation or catch-up courses put in place for foreign students can also be successfully used for these students.

VUB is also putting in place continuing and vocational training through “Universitaire Permanente Vorming” and Nova Academy, which is also a joint initiative with Universiteit Gent and Universiteit Antwerpen.

The Eutopia programme will also contribute to the development of continuing education.

The organisation of the faculty has improved: the role of the academic director is clear and useful. The Faculty Office contributes a lot to the atmosphere of the faculty.

The governing bodies of the faculty are well-embedded in the governing bodies of the University. The students have a strong role in the management of VUB, it has a student co-governance model.

Representatives from businesses are members of the FIRW course councils. However, if a formal industrial advisory board existed, this could better ensure the sustainability of work field meetings. The management of BRUFACE is also clearer than previously. A specific committee is in place (BSPC) and a joint Faculty Council is organised each year.

VUB has a good reputation among the student population: the image of small groups well-coached by teachers is associated with VUB. However, in recent years there has been a decline in the number of students enrolling in the bachelor's programmes. In 2019 the faculty conducted a study to identify the secondary schools where it could recruit and has put in place actions that are becoming fruitful: the 30% decrease observed since 2015-2016 has been improved in 2021-2022. To reverse this trend, the faculty recruited an additional staff member last year dedicated to the recruitment of new Belgian students. It also supports secondary school teachers: a pilot initiative has been implemented in an Etterbeek secondary school (near VUB) where VUB teachers invest themselves. If the conclusions are positive this initiative will be extended. The number of female students in bachelor's programmes could also be increased, even if the influx of foreign female master's students can, in some fields, compensate for this.

The second initiative is the plan to create an English bachelor's programme in engineering. Due to language regulations imposed by the Flemish government, the number of programmes that can be organised in English are limited, creating the current situation for the faculty that the sole way it can be created is in partnership with another university. The expert panel found that this is a very good initiative that needs to be supported for the future.

The website interface is common for all BRUFACE master's programmes but differs for the MSc in Photonics Engineering (common with UGent) and for the MSc in Applied Computer Science (only

in VUB). In general, this website is up to date but in some cases information must be cleared for the sake of potential students.

Human resources can be considered as a difficulty for the future, even if joint programmes have the advantage of combining the human resources of the institutions. The problem is even worse in some fields, regarding teaching assistants rather than professors.

The staff ratios (students/human resources) are as follows:

- 20.3 students per professor;
- 2.83 students per Assistant or Graduate Research Assistant or teaching staff;
- 16.53 students per Technical or administrative person.

Assistants under the supervision of professors teach practical work, exercises and coach projects. These activities together with the training they receive in parallel are appreciated when they want to pursue their career at the university.

The training of the teaching staff is very well organised and mandatory for new professors. It is strongly encouraged when the teacher receives negative feedback from students and regularly encouraged for all teaching staff members. This way of operating proved to be very positive during the COVID pandemic because nearly all teaching staff members can now manage hybrid teaching. The faculty also has a number of Emeritus professors that continue teaching, for example the catch-up courses for foreign students.

The facilities are up to date in all disciplines because they are also used for research.

The allocation model entails that the funding of the university by the government depends on key performance indicators (KPI) encompassing both education and research. This system is implemented with a closed envelope introducing strong competition between institutions. At VUB, 50% of the allocated budget relates to education and 50% to research KPIs. A similar model exists at the faculty level.

It is the reason why research funds obtained through research projects also benefit education.

Analysis summary - Mission and organisation

Strengths:

- Pleasant living and working conditions on campus;
- The university has a specific and positive image: small and human;
- Best practices on teaching shared at faculty level;
- The BRUFACE initiative is well designed;
- VUB and ULB are in the process of aligning procedures;
- The training of teachers is of good quality;
- Good cooperation with other Belgian universities;
- Pilot project with the secondary school of Etterbeek.

Weaknesses:

- The BRUFACE initiative needs to improve its communication and a data storage to monitor key performance indicators (KPIs);
- The human resources of the faculty are not increasing.

Risks:

- N/A.

Opportunities:

- Plans for a new English taught bachelor's programme in engineering;
- Industrial advisory councils could be a plus for the faculty;
- Collaborations with Brussel's communities;
- The Eutopia programme could help increase incoming EU students.

Quality and continuous improvement approach

The Quality management policy is handled at university level, under the responsibility of the Rector and the Vice rector for Education & Student Affairs, reported via the recently implemented Educational Quality Council, to the academic council. The “VUB Quality guide for education” is the reference to be applied. The quality management organisation and process are clearly described. Risk management is also organised at the university level. Internal auditors lead regular analysis on risks and mitigation actions.

Due to the estimated maturity of the different programmes, the quality management approach has moved from a system of control to a system of support for continuous improvement based on a reduced set of objectives based on 3 to 5 key performance indicators (KPIs), tailored for each programme on a three-year strategic plan. The CTI guidelines for improvement are part of the action plan.

The Faculty Quality Advisor supports the programme coordinators to develop and tailor relevant KPIs, and priorities, but the Course Council is responsible for the strategic plan. The system is based on trust in the Course Council, to encourage self-improvement. Examples of strategic plans have been provided to the CTI evaluation team. Since the last academic year, a forum gives the opportunity to the person chairing the Course Council to share practices and concerns.

To pursue harmonisation, a new tool called “fact sheets”, consisting of a common set of data, is available to the Course Council, so that different programmes can compare their respective situation yearly on the same basis, and the Faculty Education Council as well. The strong involvement of the Faculty Quality Advisor in the Course Councils and at the Faculty Council level fosters smooth communication through the different levels and spreads best practices from one programme to another inside the faculty or other faculties of VUB and ULB.

Steering the quality of education is also based on the results of surveys from students to teaching staff.

The processes and tools exist, but they didn't completely demonstrate their efficiency, due to the following constraints, raised through the discussions, that could explain the low participation rate:

- The course survey doesn't take place at a proper time from the students' point of view, it takes place too long after the course is over, so they don't consider it that much;
- The tools used for a course evaluation depends on the assignment of the teacher: VUB or ULB model; in the BRUFACE programmes they are not harmonised, which does not encourage students to participate;
- The results of the surveys are posted on a platform but not directly shared with the students, according to them;
- Part of the students are not really aware of the yearly survey evaluation process of their programme.

The survey for alumni takes place every five years, one of the reasons for a very low participation rate (30% on average), so the results are not relevant.

The difficulties linked to the differences between the ULB and VUB quality management processes and rules are well considered by both of the University Councils, as a need for improvement.

Nevertheless, some changes in the rules seem impossible for the time being.

Close communication across their respective quality advisors and course councils are encouraged to try to deal with some concerns and propose relevant changes.

The VUB quality management is anchored at the university and faculty level; organisation and processes are clear and documented. The willingness to help self-improvement at the programme

level is to be highlighted as a good approach to spread quality at the operational level. Nevertheless, the evaluation team was not convinced that steering the KPIs was clear for every course council. The new “facts sheet” is considered a good tool. The course and alumni surveys need to be redesigned to become tools for continuous improvement. Thanks to the close communication between students and teachers, informal feedback exists and is taken into account for the development of the quality of education.

Analysis summary – Quality and continuous improvement approach

Strengths:

- The quality management is handled at university level;
- The quality monitoring is present at different levels of the organisation and staff;
- The strategic plan at programme level includes relevant key performance indicators, in the hands of each Course Council;
- The strong involvement of the faculty’s Quality Advisor to support the course councils on quality improvement;
- A quality management based on trust;
- The faculty’s Quality Officer is aware of the main expected improvement.

Weaknesses:

- Differences in maturity levels of steering strategic plans and key performance indicators of different course councils;
- Student evaluation process and tools are not harmonised across BRUFACE programmes;
- Lack of efficiency of the course evaluation and feedback process and tools;
- Students are not really aware of the yearly evaluation survey of their programme;
- Response rate for alumni surveys are still too low to be relevant.

Risks:

- Discrepancies with the ULB quality system.

Opportunities:

- Exchanges on best practice with ULB to improve the quality management.

Outreach and partnerships

The chairs of the course councils and the teaching staff use their industrial networks to ensure that teaching modules are representative and industrially relevant. The VUB Fellowship Programme engages a diversified network of dedicated experts and leaders in their field who are committed to the university; this creates a strong link between industry and academia. The Faculty of Engineering has 13 Fellows, 20 Honorary Fellows and hosts three Academic Chairs.

The internship programme has experienced an increased interest in recent years: around 15 summer internships.

Professional field representatives sit on the course councils. To have a regular input, separate meetings, so-called work field inquiries, are organised to discuss issues from the corporate world and industry related to the educational programmes. However, a regularly organised Industrial Advisory Board should be welcomed in many programmes.

“The education at VUB is research-driven”. Sixty faculty professors are members of 15 VUB research groups. Regarding ties with education, the research laboratories of ULB are also involved in the BRUFACE masters’ programmes as well as many private laboratories to which some professors belong (IMEC, etc.). All are very active and recognised in their own fields, obtaining many grants at the local and European level.

The extent of the research activities can be described not only by the number of PhD students (370), of which approximately 50 defend their doctoral thesis every year, but also by the high publication output (more than 750 publications per year), which means about 11.4 publications per year per professor. Moreover, the research budget for the VUB laboratories is on average over 20M€ per year, which means 323K€ acquired through an external research budget per year per professor.

A large part of this budget is funded by external organisations and faculty members are also recipients of prestigious research grants (ERC, Methusalem grants).

Professors introduce key findings and current trends of their research field in their courses at the master’s level and even before. PhD students, whether paid by external funds or supported by the university, are engaged in teaching activities with diverse rates.

VUB, and particularly the Faculty of Engineering, is strong on innovation: over 40 spin-offs have been created at VUB, of which 19 at the Faculty of Engineering. The faculty is supported in the valorisation of scientific research by VUB TechTransfer.

VUB’s Industrial Research Fund (Industrieel Onderzoeksfonds – IOF) is a competitive funding channel in which innovation, valorisation and the multiplication factor are important criteria.

At the educational level, entrepreneurial courses are offered in the various programmes.

Innovation and entrepreneurship are mostly promoted among students during projects: very often their tutor works on projects of these spin offs and in some departments many graduates are involved in them.

The Course Council representatives are continuously setting up bilateral agreements with preferential partners and put a term to cooperation with those partners where problems occurred. These bilateral agreements are initiated at the programme level. Because they are also linked with research interests, each programme acts independently of the others within the faculty. Concerning double degree agreements, the objective is not to increase the number of partnerships but rather to work on complementarity.

This strategy combined with the decision of the faculty to choose the English language as the reference for teaching all the master’s programmes, contribute to an increase in the number of foreign students. The challenge was to improve the level of enrolled foreign students. To do so, the heads of each programme have identified some countries with students with a good success rate and are planning to set up agreements with institutions in these countries. There has been a steady increase in the number of foreign students over the last 6 years.

The Faculty management thinks that Eutopia, a European higher institutions network, and learning communities within the network, such as on additive manufacturing of construction materials, could be a tool to attract more European students in some master's programmes, such as Civil and Architectural Engineering.

Since 2019, the faculty employs a full-time policy officer in charge of internationalization. This person has had a key role in the improvement of recruitment of international students, establishing common procedures for the first part of this recruitment. This can be again improved but all internal stakeholders agree with this and recognize the importance of this new staff member.

In 2018-2019, a guide was produced for students, presenting outbound mobility.

These 2 initiatives raised the outgoing student mobility by 33%. Some programmes (such as the Photonics Programme) took the initiative to appoint an administrative & technical staff member paid by the Photonics Department to promote the programme and to pre-screen applications. A buddy-system or a catch-up programme was also set up in some programmes to help students with the difficulties they might encounter. For example, some on-line basic photonics courses are offered before the start of the first master's year in order to standardise knowledge among the students and in other programmes, Saturday catch-up courses are organised for international students.

The faculty would also like to be able to distribute more scholarships to high-level international students, to increase the appeal of the programmes. One leverage would be to have the university foundation help to raise funds for outstanding students from abroad: since the programmes agree that international students are the best ambassadors in their countries and institutions of origin, they also promote networking among previous international students.

The VUB has progressed to share support staff for international students among faculty programmes and to exchange on best practices among programmes (sustainability, on-line teaching, international support for incoming, outgoing students, etc.)

Students and employers stressed the fact that education in Dutch at the bachelor's level and then in English at the master's level develop the multilingual and multicultural skills needed to be employed in Belgium.

All evaluated programmes are based on a networking policy. VUB understood very early on that -due to its location in Brussels where only about 10% of the population is Flemish- it would be difficult to survive without strong cooperations.

As such, partnerships were established a long time ago and they are well alive and improving. Five programmes with joint degrees now exist with ULB, 3 with UGent, 2 with KU Leuven. The programmes taught in English help attract international students.

Analysis summary - Outreach and Partnerships

Strengths:

- Fruitful improvements to improve the procedure to select international students;
- Good relationships with companies and industry;
- Good relations with many other Belgian universities;
- Entrepreneurship education present in all programmes.

Weaknesses:

- N/A.

Risks:

- The level of international students.

Opportunities:

- An English taught bachelor's programme in engineering to attract students from high schools.

Educational process regarding all programmes

The deliberative bodies of VUB and the Faculty of Engineering have defined and approved academic regulations, as the basis of the rights and duties of students and staff. These regulations are public and communicated to the students on their arrival at the school.

The bachelor's programmes in engineering offer specific pathways of approximately 35 ECTS (the size of each specific pathway is not exactly the same for each bachelor's programme and these specific tracks often partially overlap with other bachelor's programmes) that prepare towards each specific master's programme. Due to this organisation, the master's programmes really "begin" in the third year of the bachelor's degree. It is however possible to bypass this path for parallel admissions. The master's programmes in Electrical Engineering, Civil Engineering, Chemical and Materials Engineering, Electromechanical Engineering and Biomedical Engineering benefit from this transition to the master's level in their field.

All programmes are assessed within the scope of external quality assurance initiatives: Discipline-specific learning outcomes are defined by and in consultation with programmes that fall under the same discipline. To make sure they are aligned with the relevant professional field, representatives from industry are also consulted and the Dutch-Flemish quality assurance agency NVAO validates these Learning Outcomes and publishes them on its website.

Moreover, the BRUFACE joint programmes must comply with regulations defined by both the governments of the Flemish and French speaking Communities.

Students are highly involved in the process of designing and updating the study programmes (1/3 of the votes in the Course Council) but also through the focus groups linked to quality.

There should be one representative from the professional field in each Course Council, but sometimes these representatives cannot manage to be present during office hours. In addition, separate meetings called work field inquiries take place, the agendas depending on the specific master's programme, which makes it difficult for all the representatives to attend. This should be improving now.

The procedures for designing and updating the study programmes are described in Curriculum Building Guidelines (Richtlijnen voor curriculumopbouw). These procedures are strictly followed.

A skills matrix exists for each programme (there must be at least one intersection between each expected outcome and one of the specific courses); curricula and educational objectives are publicly available on the university's website.

In general, the website contains all information needed for potential students.

The student workload remains an issue. A systematic survey is organised each semester and focus groups take place on this subject. The fact that following the COVID sanitary crisis, many activities are organised both physically and online helps students to better organise their agendas. This hybrid system is appreciated and has allowed teachers to implement "inverted classes" to prepare courses prior to physical course sessions, allowing them to focus on more difficult subjects in the latter. This is appreciated by internal stakeholders, but the faculty must be careful not to use this freedom to prevent students from attending the electives they have chosen.

All Master of Science in Engineering programmes include a master's thesis in the last semester of the master's programme for which students are awarded 24 or 30 ECTS credits. Subjects proposed for the thesis are sometimes linked with industry concerns but are highly oriented towards research. The master's thesis experimental work is conducted with research laboratories of the faculty that are very well equipped: students have access to state-of-the art research facilities and they can use research equipment (under supervision). Some of the best master's thesis work is published in peer-reviewed journals. It is to be noted that in some departments,

laboratory work and projects are carried out where research is taking place (for example in Chemical and Materials Engineering and Electromechanical Engineering), which stimulates the taste that students can get for research. Training for the final master's thesis is also carried out via a mini-project during the first year of the master's programmes. Practical work is often organised as "mini projects", which are highly valuable from a teaching standpoint.

Some courses are also directly linked with research activities (for example the Research in Photonics course, 6 ECTS). Approximately 20% of the students pursue a PhD degree at VUB or elsewhere after graduation.

As in all Flemish universities, education is closely linked with research. Entrepreneurship is proposed through specific tracks in all master's programmes with the help of VUB TechTransfer.

The percentage of foreign students is very high, making each course an international experience. However, the teaching staff members go further in multiculturalism in some programmes, requiring the students to have groups made up of one Belgian student, one EU student and one non EU student. As foreign students are very well monitored this seems to generate few problems. The procedure for recruiting foreign students has improved including interviews and if several people are interviewing, they have a standard list of questions to ask.

There is a real effort to introduce sustainability in the technical part of each programme. Strategic Goal 3 in the faculty policy plan (SER Annex 2.01) should also include ethics. However, as employers still ask for more education in this specific field, perhaps this will make things improve.

In general, social issues are taken into account in a percentage that employers appreciate.

Many projects are included in each curriculum, and some teachers are people working in companies or even in start-ups created at VUB.

Internships that are not mandatory can be short or long, but for the time being, there is no uniformity in their organisation. This standardisation is a current challenge for the faculty.

VUB encourages all their students to participate in student life. More than 50 student organisations are managed by students in bachelor's and master's degrees. The 'Polytechnische Kring vzw' (PK) is the student's association of engineers at VUB. All organisations are itemised on their website: <https://wearestudent.vub.be/>. For instance, students plan parties, sport events and a Gala. The Job Fair is run by students and the administration.

The school provides resources and services to help the integration of new students and the well-being of all students. A student residence and sports field are available.

International students can receive help organising their arrival, with their visa or to find an apartment.

The students in a BRUFACE programme can also use all the resources on the ULB campus.

Study guidance is organised in group sessions and tutoring services are provided by selected students supervised by their teachers. Individually each student is followed by the learning path counsellors of the Faculty. This part of the organisation works well, but the expert panel noticed that students do not always know which service is at their disposal (for example the Career Guidance centres).

The small size of groups allows for oral examinations that are appreciated by the students but are time consuming for the teaching staff. Assessment is considered by VUB as an integral part of the learning and teaching process and as an opportunity to verify to which extent students have achieved the intended LO.

The assessment policy is clear; it is a part of the quality assurance process.

Analysis summary – Educational process

Strengths:

- Trust between students and staff;
- The small size of student groups;
- Very internationally-oriented programmes;
- Improvements have been implemented to improve the procedure to select international students;
- Good support of education by research teams.

Weaknesses:

- The workload of some Teaching Assistants in some disciplines could cause problems;
- Very diverse teaching platforms used by the staff, this is a problem for students;
- The percentage of responses to student surveys is still very low.

Risks:

- Possibility of gaps in knowledge expected for the master's programme when students have an international educational background.

Opportunities:

- Teach more ethics in the programmes.

Educational process regarding the different programmes

Bachelor of Science in Engineering

In 2022, there are 55 students enrolled in the 3rd year of the bachelor's programme (of a total of 178 students). This number has decreased from 227 in 2015-2016 despite the introduction of a biomedical option, while the success rate (a bit less than 80 % in the third year and more than 55% over 3 years) and drop out rate (more than 45 % mainly during the first year) have not changed during this period.

The level of basic scientific knowledge at the entrance is assessed through a "mandatory test" for 4 courses at the beginning of the 1st year, but student recovery of their shortcomings is still an issue because online remediation is not always followed and is not mandatory.

Increased flexibility in the individual curricula and rules on GDPR lead not only to a greater administration burden but also more complexity for the students followed up by the teaching staff. A buddy project (students in 3rd year or after, supporting newcomers) on top of study guidance programmes has been developed in order to provide additional support. These programmes have to be followed by about 2/3 of them in the first year as soon as possible not to lose too much ground.

The bachelor's programme gives a solid scientific basis on a wide scope (theory, experiments, techniques).

Ethics, sustainability and soft skills are presented in the 1st year in the engineering skills module that also encompasses measurements, experiments and mathematical techniques.

The 2nd year, through technical projects aligned with master's options, provides a glance at the research and at least a concrete application exercise in small groups.

During the 3rd year, an option for a master's among the five possible ones is becoming pre-dominant alongside other general disciplines involved.

Dutch language penalises understanding if it is not the native language of students. Of course, English is more popular and could help to attract more candidates.

Development and monitoring of the educational project

For a bachelor's degree, only some lectures exist at the initiative of the professor (e.g. chemistry) or during the environmental conference in the engineering module in the 1st year. Still, theoretical courses use very modern means (blended learning) and the use of PhD students to conduct and correct exercises or experiments allows for a very short loop with the professor. The programme is often reviewed (each course every 2 to 3 years).

Curriculum: programme outcomes and learning outcomes

The programme matrix is very precise, and a detailed course unit description is also available. The programme matrix provides the programme with an overview of the path. The individual courses contribute to the programme-specific learning outcomes and describe which teaching methods and types of assessment are used. There is no internship in the bachelor's programme.

European regulations are followed (Flemish rules through Dutch-Flemish quality assurance agency NVAO) knowing that this bachelor's programme is not the end of the learning process: it is normally followed by one of the 5 master's programmes corresponding to the track chosen during the last year of the bachelor's programme.

The programme is based on lectures, practical work and tutorials, completed by technology projects.

Real-life practical problems and solutions are not addressed except in projects because they are dedicated to the master's programme.

Programme implementation

Academic regulations are defined with all the special cases, rules, feedback to students. Given their complexity, the VUBUDDY project makes sense. The timetable is by semester with 2 reviews of results accordingly.

Only projects in small groups (4 to 6) in the 2nd year are in line with research departments.

Even at the bachelor's level, experiments and tests prepare students to conduct inductive reasoning. Education is mostly based on multidisciplinary research and delivered by research professors and their assistants in most cases.

Most of the students are from around Brussels, as courses are delivered in Dutch, which could be a "language barrier" to student numbers and multicultural aspects at the bachelor's level. A bachelor's programme taught in English would be a way to solve both issues.

Outgoing mobility after the bachelor's for a master's is the remaining possibility, with contribution to the university campus where a lot of foreigners come for their master's.

In the 1st year, in the Engineering Skills module (5 ECTS), courses are given by representatives from industry.

Educational engineering

After the COVID sanitary crisis, and to reduce the number of hours on campus, blended learning has been put in place and it is very well appreciated even if everybody is convinced that "only online" does not work.

In the 2nd year, the four projects in small groups (12 ECTS) aligned with tracks in master's programmes foster a multidisciplinary approach.

Being a bachelor programme, the programme is still science-based, but with technology learning (exercises online, coding, modelling, simulation, etc.) and technology projects (during the COVID

pandemic prototyping at home). Teaching methods are very well balanced (blended learning, PhD students for practical work and exercises, exercises in small groups, etc.) with a very short loop with the teacher without waiting for the end of the course. Also, flexibility with the exams or project deadline agendas exists because student representatives can discuss them with the teachers, in case of overload.

Student life

The university campus is well-appreciated with various possibilities of small “circles”. Bachelor students are given priority for accommodation. However as they are from the region, a lot still live “at home”. This reduces student life a bit. Partial online work and registered courses are compatible, with one hour to travel to the campus and so they keep their high school friends. The result is that less cultural and social networks exist.

Student guidance and programme completion

Exam regulations are very clear and students are well-informed of the different rules (transition from bachelor’s to master’s level, repeat a year, repeat a course). They would be keen to get some more feedback before exams, especially during the first year.

Analysis summary – Bachelor of Science in Engineering

Strengths:

- Well-balanced curriculum (projects, engineering skills);
- Pleasant living conditions on campus;
- Positive image of the university;
- Students feel listened to by the faculty: great accessibility of professors and assistant professors;
- Short loop between students, PhD students and professors;
- Platform for blended learning shared with other Flemish sites.

Weaknesses:

- Recruitment of students remains a weak point;
- Lack of attractiveness;
- Lack of opportunities for meetings between teachers and students during the first year;
- Weak focus of communication on the use of remediation (online) after the test;
- The timing of the communication between administration and students (seems late to the students).

Risks:

- Failure rate in the 1st year;
- Political barrier preventing the establishment of an English taught bachelor’s in engineering.

Opportunities:

- Engineering Bachelor’s taught in English;
- Recruitment of a specific person dedicated to attract students, with a specific budget and a policy dedicated to attractiveness;
- PhD students teaching exercises and projects.

General structure of the programme

The Bachelor of Science in Engineering: Architecture programme aims at providing students with a broad level of skills within the field of both architectural and engineering sciences. Strong training in fundamental sciences serves as the foundation for the acquisition of a diverse set of knowledge and skills related to engineering sciences and their application in the built environment, while the courses on architectural sciences incite students to understand and critically reflect on the theory and history of architecture. All this is integrated in the Design Studio, which is the central learning path of the programme.

The main changes that have been implemented since 2016 relate to the establishment and further development of learning paths. The “Design Studio” learning path enables the alignment of the various subjects and project deadlines. The learning path “Structures” was adjusted in various consecutive courses, and the “Building Technology” and “Computer Aided Design” learning paths are going through an in-depth renovation.

The number of new enrolled students is around 30 per year, which has been relatively steady in recent years.

Development and monitoring of the educational project

This BSc educational project aims at meeting the needs of technical and industrial skills from architectural design firms and the construction industry. The professional skills are outlined and the target job market can be national or international. However, architectural design firms and the construction industry usually require an MSc degree to hire Architectural Engineers.

The programme is developed cooperatively with internal and external stakeholders and gives good preparation to the students to proceed to the master’s programme in Architectural Engineering.

Curriculum: programme outcomes and learning outcomes

The link between each of the curriculum’s teaching units and the targeted skills is formally established in a cross-tabulated table and is consistent with skills required for Architectural Engineers. The syllabus is designed in consistency with the Bologna process, in particular with the European Credit Transfer System, the Diploma Supplement and the European regulations concerning the organisation of the programme, courses, awarding and earning credits.

Students are clearly informed of the objectives for each course in terms of learning outcomes.

The emphasis on the basic sciences represents 31% of the total number of ECTS (1st year = 30 ECTS; 2nd year = 26 ECTS), which is appropriate.

The emphasis on science and techniques in the field of Architectural Engineering represent 67% of the total number of ECTS (1st year = 27 ECTS + 2nd year = 36 ECTS + 3rd year = 58 ECTS), which is appropriate.

The emphasis on languages and human, economic, social and legal sciences represent only 2% of the total number of ECTS (3rd year = 3 ECTS), which is not much but we can consider that sustainability, circularity and innovation are embedded in the technical part of the programme.

The programme does not include mandatory internships but, as the learning activities reproduce real-life problems and experiences, the students succeed to get in touch with professional training.

The syllabus is available internally and externally. It is clear and structured into teaching units. For each unit, the syllabus shows the number of hours of classroom time per teaching method (classes, tutorials, practical work, projects) and the estimated time of personal work for the student. Each unit is also defined in terms of learning outcomes which, when validated, give rise to ECTS credits. The link between each unit and the skills is explained. The number of ECTS credits assigned to each unit is indicated and related to the overall volume of work expected, although, in some cases like Design Studios, the number of ECTS underestimates the required workload.

Programme implementation

Although no mandatory internships are included in the programme, the programme learning activities reproduce real-life problems and experiences, allowing the students to get in touch with reality. The architectural engineering projects address concrete challenges in existing locations, seeking connection with ongoing debates and engaging with the society. In addition, guided visits to construction sites and companies are organised in the framework of several courses.

The initial training in Architectural Engineering that this BSc provides, like the other degrees in Engineering, enables students to carry out fundamental and applied research activities and, from there, to establish inductive thinking and apply them in academic or industrial research environments. Several courses like “Form-active Structures”, “Architectural and Construction History”, “Circularity”, “Building Materials” and the “Design Studios” expose students to creative design, research, innovation and business thinking.

VUB benefits from its location in Brussels where people from all around Europe and the world live, resulting in a population with a diverse socio-economic and cultural background and providing the opportunity for training in an international multicultural context.

Despite that privileged location, most of the enrolled students are Flemish speakers from Flanders and the Brussels region and only a few are international. Although some shared courses with the ULB promote multilingualism (French and English), the Faculty of Engineering seeks the possibility of organising a bachelor’s programme in engineering taught in English and master’s programmes, to attract more international students and fulfil the aim of offering predominantly international educational programmes.

Regarding students’ outgoing mobility, in the first semester of the 3rd year of the bachelor’s programme, the Erasmus Coordinator informs the students about the possible Erasmus exchanges during the master’s programmes, resulting in carefully prepared study abroad monitored by the faculty.

This bachelor’s programme addresses the major medium- and long-term issues of sustainable development, social responsibility and ethics from the very beginning. From the first year the students are immersed in an atmosphere that invokes the responsible attitude towards the built environment and society in general and are encouraged to reflect on the impact of their design decisions. Sustainable building and circular economy principles are dealt with in-depth in a cross-cutting manner in the three “Design Studio” courses as well as in the courses: “Building Systems”, “Light and Lighting”, “Light and Visual Environment”, “Materials Science”, “Bioclimatic Design”, “Form-Active Structures”, “Building Materials” and “Environmental Aspects of Engineering”, among others.

Educational engineering

The Bachelor in Architectural Engineering uses teaching methods adapted to the skills, using a multidisciplinary approach in several situations, including projects, case studies, design and problem-based learning. The emphasis is placed on student-centred teaching methods and innovative teaching techniques are encouraged, developed and shared. They are regularly evaluated. The faculty has a teaching innovation plan integrated in its Strategic Plan.

A significant portion of the programme (38%) is partially delivered by professionals together with professors and teaching assistants. The programme uses project-based teaching and relies heavily on concrete situations and activities within joint projects.

VUB and the Faculty of Engineering encourage and support the students’ associative experiences. A good example, in the framework of BSc in Architectural Engineering is the “bru:ecture” student’s organisation that is very active and organises several activities related to Architectural Engineering. In addition, the space called “atelier” is open to all the students of the Bachelor in Architectural

Engineering and they use it not only to develop their work for the various Design Studios but also to interact and collaborate with other student groups.

Student guidance and programme completion

The so called “Class Council” that includes professors from crucial courses is in close contact with the students, checks results and provides personalised guidance. If and when needed, subsequent actions are taken providing help to students who need extra support.

The method for assessing skills and learning outcomes is based on previously defined, publicly available criteria.

The degree is awarded in compliance with laws and regulations, ensuring that each graduate has achieved the level of development expected at the end of the programme for each skill of the programme.

The diploma supplement is issued to each graduate, describing the individual pathway of each graduate and may include details about the personal activities such as mentoring, as well as additional academic or professional training.

Analysis summary – Bachelor of Science in Engineering: Architecture

Strengths:

- Previous guidelines for improvement of CTI were addressed;
- Good gender balance;
- Transparent, clear and balanced teaching vs research load for assistants;
- Advanced use of digital tools in the programme;
- Focus on sustainability from the first year of the programme;
- Studios are near the offices of professors, assistants and researchers.

Weaknesses:

- Official evaluation of courses by students is not representative (small number of responses) and not set at the right time, so the evaluation feedback loop could be ineffective;
- Credits do not always correspond to the real workload.

Risks:

- The number of students is low; a decrease would be problematic even if increasing the student numbers implies changing teaching methods;
- Latency on transforming a trend into courses, on adapting to new technologies.

Opportunities:

- Improvement of the skills of students to work on digital environment.

Master of Science in Electromechanical Engineering

In initial engineering training under student status

General Structure of the programme

VUB and ULB offer a combined curriculum in Electromechanical Engineering (EME).

The objective is to train students to become multi-disciplinary problem-solvers in industry, taking into account the social, ethical, economic and environmental impacts of their choices.

The programme consists of common or partially common courses, specific courses for the 5 options, various elective courses or internships (40 or 60 days – 6 or 10 ECTS respectively), a project in the first year of the master's programme (MA1) and a master's thesis in the second year of the master's programme (MA2). The 5 options are:

- Aeronautics (aircraft design, construction, exploitation and maintenance);
- Robotics and Mechanical Construction (former Mechatronics-Construction) (conception, design, manufacturing and control of mechanical/electromechanical devices);
- Sustainable Transportation and Automotive Engineering (former Vehicle Technology and Transport) (all aspects to address societal challenges, optimal energy consumption, climate change, air quality, etc.);
- Energy (energy systems and components to supply it in a reliable, affordable and sustainable way);
- Operation Engineering and Management OEM (former Management and Technology) – only at ULB (planning, design, production, use and recycling of engineered products and systems).

The EME master's programme has recruited an increasing number of students for the past 5 years: 132 for the year 2022 vs 99 three years before. The number of students registered for the EME master's for 2021/22 is quite balanced between the 2 universities: 48% for VUB and 52% for ULB, including the Operation Engineering & Management (OEM) option. The average for the past 7 years: VUB 46%, ULB 54%.

It should be noted that the number of students in the OEM option has been decreasing for the past 5 years from 14 down to 7.

The programmes have been updated since the last CTI evaluation, but the Aeronautics course is to be updated in 2022-23. For the common part of the master's programme, in MA1, a new course (Data Driven Engineering) was introduced, which is well perceived by both students and industry. Most of the courses are a mix of formal teaching and project-oriented training. They are delivered in English. Internships where students can experience the real work environment, are recommended but not mandatory. These are well appreciated by students as well as by companies.

In the past 3 years, between 85% and 90% of the student population has been male. The students admitted have a bachelor's degree, complying with the pre-requisites of this EME master's programme. For some students from "pure mechanical engineering" schools; an extra catch-up course (above the 120 ECTS of the master's) of 6 ECTS is given with subjects such as System Analysis, Electronics, and Control.

At VUB the specialisation in Electromechanical Engineering starts in the third year of the Bachelor of Science in Engineering in order to prepare the students for the master's and thus, reduce failure in MA1. The bachelor's programme gives the students a proper level in Math, Physics, Mechanics, Electrical Engineering and Chemistry and other dedicated courses and topics.

Development and monitoring of the educational project

Professors, assistants, students, alumni as well as representatives from industry are involved in defining the programmes. VUB also has experts and leaders grouped in a Fellows programme that advises the educational projects. Interviews are organised to collect input from the industry. ULB calls on a Strategic Committee.

Companies seem to appreciate the switch of teaching language from Dutch to English so that students are well prepared for acting in an international environment.

The alumni survey indicates that 85% were aware of the fundamental and cross-disciplinary skills from the beginning of their studies or got to know them during their studies; and 90% acquired the necessary skills during their study, the remaining 10% had a neutral answer.

Curriculum: programme outcomes and learning outcomes

VUB/ULB have formalised the links between the teaching units and the targeted skills for the students in a quite large matrix. Pre-requisites are clearly defined. Basic training to succeed in MA1 and MA2 are specifically given for the EME in the third year of the bachelor's programme.

VUB/ULB are very sensitive to the proper transfer of the technical content of the programme to its students and monitors it closely. All objectives of the different courses are clearly presented to the students. Hard skills acquisition remains the main objectives of teachers and students through formal lectures, exercises, and projects mostly managed in small groups of three people (a Dutch and French native speaker and an international student).

Soft skills are mainly transferred through written project reports, oral presentations, visits of industries, labs (including ethics, finance, commercial law basics, safety, security, critical sense of their work, etc.). Students are more eager to learn soft skills through practical examples in the framework of courses or projects than by having formal lectures.

The Syllabus was only partially included in the self-evaluation report, part 2. The master's totalizes 120 ECTS and a model schedule of the courses during the two years, each counting for 60 ECTS, is proposed to the students.

In MA1, there are:

- Common and partially common courses depending on the chosen option (36 to 45 ECTS);
- Specific courses with ECTS varying from 20 to 24 depending on the chosen option;
- 5 ECTS for the MA1 project.

In MA2, there are:

- Partially common courses;
- Specific courses, from 9 to 20 ECTS depending on the chosen option;
- Elective courses, from 11 to 20 ECTS depending on the chosen option;
- Master's Thesis for 24 ECTS.

In the provided documents, ECTS credits were globally mentioned per year but not assigned to the different courses. The number of hours was not mentioned either, this should be improved. In the Teaching and Examination Regulations it is defined that the student workload for 1 ECTS ranges between 25 and 30 hours.

A detailed updated and complete syllabus was happily given by the BRUFACE team after the site visit.

Programme implementation

The programme is well-documented and all information is accessible through both university websites. Future students can have a clear image of the programmes and academic regulations before enrolling in the bachelor's or master's programmes.

The "2021-2022 Electromechanical Engineering" brochure clearly presents the programme to future students but there is no detailed ECTS assignment in the master's programme between the 5 main courses, choice of one major (option), project in MA1 and the master's thesis in MA2.

The teachers' decisions are based on academic results as well as on the projects and oral presentations.

The EME programme is a combination of courses delivered by university lecturers to give students the fundamental level and conceptual knowledge, and practical lab training, case studies and project work.

In MA1, the 5 ECTS project aims to develop the skills of the students in solving engineering problems. It is the first use of their newly acquired technical skills, it shows their autonomy and reporting capability, as well as their ability to deliver and well defend their written report.

Internships are welcomed by the students -even if they are not paid and work much more hours than the equivalent of hours they get for the number of ECTS- and the industry. The teaching staff supervise each student during the internship. In the 10 ECTS internship, each student must present in an interview with the jury, what he/she achieved during the internship. For the 6 ECTS internship, only a written report is required.

Research activities

Research activities start in the MA1 project where students must find information or documentation by themselves. It is further developed during the master's thesis. Thanks to the common EME programme of VUB/ULB, sharing lab facilities and research collaboration has increased.

In the period between 2019 and 2021, 18 researchers started a PhD in the EME-affiliated research teams and 7% of the graduates of the EME programme started a PhD.

Training for an international multicultural context

The EME master's is part of the BRUFACE initiative and attracts Flemish and French speaking students as well as students from other countries.

Foreign students are evaluated based on their academic background before being accepted. Around 20% to 25% are accepted versus the number of applications received. The language of instruction is common and unique: English. In 2020-2021, the programme welcomed 18 non-European Economic Area (EEA) students and 12 EEA students.

International students are supported by the Internationalisation Coordinator. Support varies from a welcome session to a weekly Q&A information session.

At the central level, other initiatives are organised to ensure proper integration, such as VUBuddy, Brussels tour, student cultural clubs, study tutoring or counselling. Teachers are eager to mix local and foreign students in all projects. Students recognise this as a good way for cultural exchange, sharing knowledge and best practice, as well as developing approach and critical sense of their work. EME international students are considered as important by Belgian industry because of the lack of engineers.

Sustainable development, social responsibility and ethics

The subject of sustainable development, social responsibility and ethics is embedded in courses, different projects and industry visits.

Educational engineering

Due to the COVID pandemic, the faculty has developed online teaching for the past 2 years, well perceived by the students who can see the courses several times and/or at different times. The combination of lectures, practical sessions and/or projects is well balanced over the 2 years. Teachers can be accessed easily for additional explanations, exchanges or recommendations.

Skills are evaluated in written form as well as oral form, allowing students to be trained on soft skills.

Student guidance and programme completion

The number of students per year remains limited, allowing for an easy direct communication between the teaching staff and students. The teaching staff can quickly tackle an issue with students having potential difficulties. The programme has identified that the Electrical Drives and Control System Design courses had a higher failure rate than others due to the non-homogenous background of the students with a bachelor's degree from abroad. Therefore, the recruitment process for foreign students has been improved and a preparation/catch-up course (6 ECTS) has been added above the regular 120 ECTS. This course is given on Saturday mornings on a voluntary basis. Students are very positive about this course.

Students are evaluated in written and oral form on a regular basis. With a large emphasis on oral examination – thanks to the medium to small size of the groups. Oral examinations allow the teaching staff to check the knowledge not only on the specific subjects but also on the overall understanding of the programme. Soft skills, such as easy communication, self-criticism of results, ethics, economics, can also be tested and better understood.

Analysis summary - Master of Science in Electromechanical Engineering

Strengths:

- Well-documented master's programme;
- Students appreciate the new EME programme, including subjects such as Data Driven Engineering, Industrial Automation, Robotics II;
- It is mandatory to work in mixed groups composed of VUB/ULB/ foreign students for sharing knowledge, experience, etc.;
- Good relationship of the teaching staff with all stakeholders (students, alumni, companies) fostering the improvement of education as well as research;
- Project based learning is well developed;
- Improved selection process of international students;
- The teaching staff is aware of other courses in the same fields and cooperate;
- The teaching staff is recognised in research cooperation.

Weaknesses:

- Combination of two administrative teams (VUB and ULB) to manage the programme;
- Lack of specification in the communication documents of the specificities of Aeronautics versus Aerospace;
- Partially divergent data on two websites (VUB and ULB);
- Different tools/platforms (teleconference, etc.) used by the teaching staff;
- Former syllabus on the website with different information published by VUB and ULB.

Risks:

- Informal Saturday catch-up course (but formally validated);
- The catch-up course strongly depends on the willingness of one person;
- Heavy workload of teaching assistants paid by the university;
- Most of the teaching assistants are PhD students and Postdoc students with a temporary contract not financed by VUB.

Opportunities:

- Improve the BRUFACE initiative visibility on a common website;
- Easy student access to information with a common platform;
- Control the increase of students to keep the friendly environment and close relationships between students and the teaching staff.

Master of Science in Chemical and Materials Engineering

In initial engineering training under student status

General structure of the programme

The Master of Science in Chemical and Materials Engineering (MScCM) has been the first experience of collaboration between ULB and VUB due to a good complementarity of both entities in education and in research and was at the origin of the BRUFACE initiative for joint degrees. It offers a unique, integrated insight into Process, Chemical, Environment and Materials Science and Technology. Students in this MScCM must choose in the first year (MA1) between 2 profiles, either “Process Technology” or “Materials”, specialising in one of them, but always paying attention to the link between the two closely connected fields. Over the last 4 years, the MScCM welcomed between 30 and 38 students per year (compared to 14 to 24 students over the three previous years). The management team of the programme is not targeting any sharp increase in the number of students, preferring to maintain close contacts with the students that they consider as a signature of the programme. Over a period of seven years, the percentage of international students has been rather significant and varies from 40% to 70% (60% to 30% for Belgian students), with a 50/50 representation of European and Non-European foreign students. Gender balance in this MScCM is rather good over the years in terms of both students and teaching staff.

Development and monitoring of the educational project

The MScCM programme is managed by the Course Council where all the internal stakeholders (students, teaching staff, assistants) are represented. Some significant changes to the courses have been introduced since the former CTI evaluation: Process Safety, one of the CTI guidelines for improvement, is now taught in the course Reliability & Risk Analysis of Industrial Installations and reinforced in some laboratory work. The Environment course has been broadened thanks to the recruitment of a new professor in the field. Campus wide electives have been introduced while less electives at the master’s level were offered. A dedicated course on Sustainability will be introduced in 22-23 for the Process Technology Profile (already exists for the Materials Profile) leading to some changes to Instrumentation teaching. All these changes were approved by the faculties and ULB/VUB ad-hoc committees.

It is needed to stress that the response rates to the student surveys at the end of each semester is quite low, particularly at VUB, and the process should be improved.

Curriculum: programme outcomes and learning outcomes

16 Learning Outcomes (LO) common to all the VUB and BRUFACE master’s programmes are completed with 2 specific LO’s for this MScCM programme:

- An integrated insight in Chemical Process and Materials Technology;
- Insight in Chemistry as a link between Process and Materials.

These are very broad specific LO’s but the faculties’ instruction is to have no more than 3 specific LO’s per master’s programme. The matrix of the LO’s vs academic activities exists; teaching and assessment methods are defined for each activity. Academic activities of a year are split into 60 ECTS clearly stated for each one. The Chemical and Materials Engineering curriculum starts at bachelor’s level (3rd year) where a specific option exists. Despite true progress in the internship rate, outbound mobility and some new elective courses to develop management skills, there is probably still some room for improvement of soft skills, better capitalizing on group work in labs or in projects.

The syllabus is available internally and externally. It is updated and clearly states the LO’s, the number of teaching hours and the number of ECTS associated with each academic activity (60 ECTS per year). The core programme common to both Process Technology and Materials profiles, starts during the 3rd year of the bachelor’s programme (with 32 ECTS associated with Chemical & Materials Engineering) and extends to MA1 and MA2 where 51 ECTS (41 in MA1 +10 in MA2) are

associated with common compulsory courses. Optional packages such as internships, further specialisation, elective courses, with a possible mix of the 3 packages (10 ECTS) complete the curriculum.

Programme implementation

About 50% of the students do an internship (of which 18% abroad) and professors clearly encourage the students to take an internship (6 to 10 ECTS). About 45% of the master's thesis' are connected to industry. Most professors have research projects in cooperation with industry, the outcomes of which are introduced in the programme. Part-time professors also work for industry (Chemical Plant Design or Sustainability of Materials for example). Company visits are planned in the curriculum mainly for the Materials Profile. Online interviews with representatives from the professional field were conducted in autumn 21 and an alumni gathering was organised in May 22. The strategic objective of the MScCM programme is to organise a yearly feedback meeting with alumni and the professional field.

Research activities, innovation and entrepreneurship training

The project conducted in MA1 second semester (1 day/week over 9 weeks and 5 ECTS) is mainly linked to research (can also be linked to Project Management). The master's thesis (24 ECTS) is clearly handled in relation to research. Most professors do research in a field closely related to their courses allowing them to introduce the most recent developments in these courses. Some courses focus on innovation (e.g. Molecular & Biomolecular Engineering and Advanced materials). Entrepreneurship is an elective option (up to 10 ECTS) where students select courses from the package offered by the ULB/VUB Business Schools. Over the last 5 years, 25% of the students took one or more courses from this entrepreneurship package. Several alumni work in spin-offs and start-ups.

Training for an international multicultural context

The programme is delivered in English. On average, over 50% are foreign students (Internationalization at home). 22% of Belgian students went abroad (14% internship + 8% outgoing mobility). There has been a strong increase in incoming students in recent years (from 1 in 16-17 to 12 in 21-22). Access to UTOPIA will create new opportunities for partnering abroad.

Sustainable development, social responsibility

ULB has a long-standing and strong experience in environmental issues and has recently decided to link additional funding for teaching on sustainability aspects. A new professor has been hired at ULB in the field of Development of environmentally friendly recycling processes. Environmental Technology and Reliability & Risk Analysis are part of the common core part of the programme. A new course on Sustainable Chemical Processes will start in 22-23 in the Process Technology profile (similar courses already exist for the Materials Profile). Elective courses allow students to gain more in-depth knowledge in the field of sustainability (e.g. Engineering aspects of circular economy, Industrial techniques for water management, etc.)

Educational engineering

With project-based & interactive training, the vast majority of courses include exercises and lab sessions or projects. Excluding projects and internships, face-to-face courses represent 50% of the teaching hours, exercises 20% and lab sessions 30%. An alumni satisfaction survey conducted in 2021 shows that 91% are satisfied with the scientific training they received in the MScMD programme, 71% with the analytical training and 100% with the problem-solving skills. Since the COVID sanitary crisis, lectures are now recorded and students can attend the courses physically or online (50 to 100% of physical attendance). A focus group with students was organised to analyse online teaching. Proposals of the group were taken into consideration by the Course Council. An initiative for getting the best from blended learning is on-going (for example in the Organic

Chemistry Lab where a video is used to raise student awareness about safety). The programme's strategic objective has been defined to make the course more attractive (integrated learning trajectory of the lab sessions - visibility of circularity, sustainability, global climate challenges – better use recommendations by CTI, alumni and industry).

Student life

MScCM organises regular gatherings between students (from bachelor's & master's programmes), professors, assistants and PhD students that all the stakeholders enjoy and that allow valuable informal exchanges. The existence of 2 different learning platforms at ULB and at VUB makes it more difficult for the international students to adapt. Teaching activities generally start at 8:00 am and end at 6:00 pm, therefore it is not easy for the students to involve themselves in campus life.

Student guidance and programme completion, employment

Despite improvement in the foreign student recruitment process (written evaluation + interview) in recent years, refresher courses in Organic Chemistry are organised at the beginning of the MA1 to cope with the different backgrounds of the incoming students. Coherence of electives is checked and has to be approved by the academic team. The number of students in the master's programme allows close follow-up of the students by the teaching staff that prevents student dropout. The biannual student survey response rate is quite low (10% for VUB and 40% for ULB). Assessment methods are well defined in the syllabus. Soft skills (written report and oral presentation) are assessed for the MA1 project and master's thesis (30% of the result). Regarding employment, the programme management team performed an assessment through LinkedIn for the alumni who graduated over the last 5 years; 41 different job sectors were identified for 101 graduates. Starting jobs: 20% doing a PhD, 14% in consultancy, 7% in academia, 7% in the chemical industry, 7% in the energy sector. Current jobs: 18% PhD, 13% energy sector, 7% chemical industry, 7% pharmaceutical industry, 7% consultancy.

Analysis summary – Master of Science in Chemical and Materials Engineering

Strengths:

- Good follow-up of the previous CTI guidelines for improvement;
- Very dedicated and involved teaching team;
- Long-time partnership between VUB and ULB Chemical & Materials engineering programmes (15 years);
- Sustainability is included in specific courses and in case studies in relevant courses;
- Link to industry is present in the programme via case studies, master's thesis topics, MA1 project, etc. and easy integration in companies for graduates;
- Active alumni community;
- Good gender balance in staff and student population.

Weaknesses:

- Different administrative platforms at many levels (schedule, satisfaction surveys, etc.) between ULB and VUB;
- Response rate for student surveys is too low especially at VUB and thus not very meaningful;
- Links with industry at programme level are not formalised (no Advisory Council);
- Lack of support by the staff for international students at the programme level, different to what is done in other programmes.

Risks:

- No clearly defined strategy regarding the number of incoming students;
- Less than 50% of Belgian students;
- Student workload (classes from 8 am to 6 pm) can prevent them from doing additional activities.

Opportunities:

- Formalise links/feedback with/from industry;
- Develop soft skills via lab sessions, internships, international experiences, etc.

Master of Science in Civil Engineering

In initial engineering training under student status

General structure of the programme

The aim of the Master of Science in Civil Engineering (CE) programme is to provide a science-based, broad and multidisciplinary education in the design, building and maintenance of civil engineering projects with due regard to stability, safety, sustainability, cost and the environment. In a strongly varying economy, the graduates benefit from being CE generalists who have an attitude of life-long learning and are able to easily reorient themselves along the course of their career. Aiming for a future-proof programme, and based on discussions with stakeholders, a new programme was developed (starting in the academic year 2021-2022) based on three pillars: (i) Sustainability (ii) Technological society and (iii) Fascinating structures. As a result, two new compulsory courses -Sustainability in Construction and Digitalization in Construction- were incorporated in the first year (MA1) programme.

The Master of Science in Civil Engineering recruits around 35 students per year. About 50% of them come from abroad. The number of Belgian students is declining. For CE, a process of foreign recruitment based on interviews has been developed for the international candidates. The process is appropriate and also limits the dropout of students during the course.

Increased recruitment of international students is to balance the decrease of Belgian students. Around 15-20 foreign students are recruited each year. International non-Europeans are also recruited for CE (from India and Pakistan in majority).

Development and monitoring of the educational project

The stakeholders included in the definition and evaluation of the programme are the students, alumni, professionals in the field (represented in the Course Council), and VUB University Fellows. Several discussions with the professionals have steered the significant re-design of the CE curriculum: the organisation of an in-depth Work Field Inquiry in October 2021 with a strong and versatile core of 14 industry representatives (alumni as well as non-alumni), a meeting with representatives of the Flemish Construction Federation.

Industrial representatives are included in the Academic Committee.

Curriculum: programme outcomes and learning outcomes

The consistency of the educational objectives is guarded by the skills matrix, linking each teaching unit of the curriculum with the learning outcomes (LO) and the teaching methods used. The CE programme combines 16 LO's common to all masters' programmes in engineering and 5 CE-specific Los such as: LO 18 "combine computational modelling methods, digital technologies and experimental techniques"; new LO 21 "design civil engineering projects that contribute to the sustainability of the built environment".

The master's general LOs include many transferable skills and attitudes that are typical of the BRUFACE Civil Engineering training received at VUB and ULB. The students, guided by both academics and industry professionals, work close to the industrial reality of designing a new building.

Aiming to form CE generalists with a strong basis for life-long learning translates into quite generic 3rd year bachelor's and 1st year master's courses. About half of the 3rd year bachelor's credits deepen the general engineering knowledge and skills, while the other courses focus on the specialisation in civil engineering.

After providing the students with the knowledge essential for a future civil engineer in the first year of the master's , they get a lot of freedom in the second year of the master's to tailor a programme according to their own preferences. The students can specialise by choosing two out of the three semi-elective blocks: (i) Innovative design of civil engineering structures, (ii) Geotechnologies for sustainable developments, and (iii) Reliability and monitoring in civil engineering.

Widening of the CE graduate profile can be achieved by the large array of elective courses in different fields: (i) Building Physics and Architecture; (ii) Structures; (iii) Water Resources; (iv) Management, Economics and Law; (v) Internship; (vi) Languages; (vii) Infrastructure and Mobility. The master's thesis can be performed either in one of the research expertise fields of VUB and ULB, or in close connection with industry. The syllabus is available on the VUB website.

Programme implementation

The large industrial network of the CE departments ensures that the industry and research internships reflect the wide career opportunities. Companies range from small start-ups (Kabandy, Zensor) and Belgian contractors (Van Laere, Democo) to leading (multi)national construction firms (Besix, Denys, Victor Buyck), and design/control firms (Bureau Greisch, Sweco, SECO). Around 50% of the students do an internship.

Many teaching units reproduce real-life experiences, e.g. Design Project in civil engineering and integrated structural design, where real design projects are investigated. In at least half of the master's courses the link to industry is made by involving teaching staff from industry, organising guest lectures and/or company and construction site visits.

Research activities, innovation and entrepreneurship training

The master's thesis is the most substantial (24 ECTS) research activity in the programme. The students have access to state-of-the-art CE lab facilities at both VUB and ULB, and cross-disciplinary equipment and expertise thanks to ongoing project collaborations with the Architectural Engineering, Mechanical Engineering, Materials and Chemistry departments and industrial project partners. On top of the MA2 elective courses, business management and entrepreneurship and business aspects of innovation in materials, and entrepreneurship is encouraged by bringing students in contact with entrepreneurs.

Training for an international multicultural context

The Master of Science in Civil Engineering is part of the BRUFACE initiative. Offering a full master's programme taught in English attracts international students as well as academic staff. In 2020-2021, the programme welcomed 33 non-European Economic Area (EEA) students enrolled for the full master's. This diverse and multi-cultural student population strongly nurtures internationalisation at home.

With regards to student exchanges within the MSc CE programme, all students have the opportunity to go abroad for studies (e.g. Erasmus+) and/or an internship. Exchanges abroad are strongly encouraged by annual info sessions and academic support. Students are supported by a dedicated Exchange and Internship Coordinator (academic profile) of the programme, and since 2019, by the Internationalisation Coordinator at the faculty level. Internationalisation is not yet in action for the Belgian students despite the endeavours of the teaching staff. The presence of international students (who don't speak French or Dutch) promotes internationalisation at home.

Sustainable development, social responsibility

The subject of environmental impact and sustainability is integrated in design courses and their related projects, including the Design Project in Civil Engineering. Because of its importance, the

programme was moreover significantly reformed to make place for the new course Sustainability in construction.

Educational engineering

In the third year of the bachelor's programme many courses are taught by a combination of lectures, hands-on labs and guided exercises. At master's level, education is often offered under the form of project-based learning, mostly through assisted teamwork. Every project attempts to activate the creativity and problem-solving attitude of the students. The iterative process of receiving feedback from academics and industry professionals, and improving the effectiveness and sustainability of the solutions, makes students critical about their work and contributes to their engaged and responsible attitude.

While several academic staff members are represented on boards of companies or organisations in the field, the CE teaching staff is also strengthened by many part-time lecturers from industry. Thanks to the combination of lectures, interactive practical sessions and project-based learning, the programme achieves a well-balanced workload throughout every curriculum year. CE students also give feedback in focus group discussions and in the Course Council. Students clearly show a responsible attitude in this feedback, as they have highlighted not only ECTS-underrated courses but also ECTS-overrated courses.

Student guidance and programme completion

In combination with the relatively limited number of students, failure management allows for smooth communication and early detection of potential issues. In addition to this, the project-based learning courses organise time for intermediate feedback on a regular basis, ensuring close follow-up of the students' learning process.

The oral formative feedback in many project-based courses during the year, as well as the oral summative evaluations that are used in most courses, distinguishes the BRUFACE CE programme from many other (inter)national CE degrees.

Analysis summary – Master of Science in Civil Engineering

Strengths:

- New CE programme, including subjects such as sustainability and digitalisation;
- Partnership with ULB in the framework of the BRUFACE initiative;
- Relationship with industry professionals to improve teaching and research;
- Project-based learning is well developed;
- Better selection process of international students;
- International flair of the programme;
- Good relationship of the teaching staff with all stakeholders (students, alumni, companies).

Weaknesses:

- Difficulty to attract Belgian students which make up only half of the students;
- Soft skills in the curriculum are not formally developed (finance and human issues, safety and security), except in the project management compulsory course;
- Lack of administrative coordination (common platform) for BRUFACE.

Risks:

- Level and courses for international students may not be completely well adapted yet.

Opportunities:

- Formalize relationship with industry professionals;
- Eutopia to develop European relationships and education in additive manufacturing in the construction industry;
- Develop contacts and agreements with design firms and engineering firms in the Brussels area in addition to construction companies;
- Introduce peer evaluation for project work.

Master of Science in Architectural Engineering

In initial engineering training under student status

General structure of the programme and development and monitoring of the educational project

The aim of the Master of Science in Architectural Engineering (AE) is to train architectural engineers who understand the dynamics between architecture and engineering. The programme is part of the BRUFACE initiative with ULB and taught in English.

The AE study programme consists of two academic years; students admitted in the master's programme have graduated from the Bachelor of Architecture and have the essential background to study this main subject. It is a broad and multidisciplinary programme based on Architectural Design, Engineering Sciences, Architectural Sciences, with a focus on Sustainability. The portion of non-traditional subjects could be increased.

Through graduation work, the programme includes fundamental or applied research activities. The final objective of the specialisation is consistent with recruitment objectives.

The number of new students enrolled in the master's programme is in 2019-2020: 97; 2020-2021: 85 and 2021-2022: 77 (27 from ULB and 50 from VUB). The number of students is decreasing. In 2020-2021, most students came from Belgium; the gender figure was balanced; 8 international students were enrolled; only 5 students went for an Erasmus+ mobility programme (but in the 3 years before the COVID pandemic the number was between 13 and 19).

The school cultivates a general atmosphere of benevolent openness in order to identify any reported problem situations; there is follow-up of students in difficulty. The rhythm of course councils seems to be an issue for the students.

Curriculum: programme outcomes and learning outcomes

The objective of the programme curriculum is for students to acquire a list of skills and associated learning outcomes, including: technical installations in buildings and calculation methods in architectural engineering, introduction of courses and seminars regarding sustainable architecture and urbanism and ethics, project development and project management (design studios), social and cultural aspects of architecture-urbanism, links between education and research. The link between each of the curriculum's teaching units, and the targeted skills is formally established. Students are clearly informed of the objective for each course in terms of learning outcomes. European regulations concerning the organisation of the programme are taken into account: course semesters, awarding and earning credits. The syllabus is designed in consistency with the Bologna process, in particular with the European Credit Transfer System (ECTS). It should also be noted that after the studies, there is a mandatory two-year internship before being able to practice as an architect.

The number of ECTS credits assigned to each teaching unit is indicated and clearly linked to the overall volume of expected workload, but it seems that this correspondence is less true for the Design Studios. There is a substantial participation of professional architects in education: site visits, lectures by practitioners, feedback on design projects by professionals.

Research seminars form an important core of the curriculum. The language of instruction is

English; it will facilitate/help the integration in international exchanges and firms.

Programme implementation

During secondary studies, no teaching touches on architecture, which justifies the continuity of the programme in 5 years and the initiation to architecture from the first year of the bachelor's programme.

The clear focus on design, including historical, cultural and social aspects gives this programme a distinctive face in the academic ecosystem.

An important part of the programme is delivered by professionals from the architecture-construction world (13 PR actioners for a total of 29 lecturers).

There is no compulsory internship: there is a mandatory two-year internship after studies to access the profession.

Research activities, innovation and entrepreneurship training

There is a strong link between the training programme and research; each member of the teaching staff is active in research. Engineering training includes fundamental or applied research activities delivered by research professors. Specific concrete activities and projects are used to expose students to innovation. Some soft skills are lacking in the entrepreneurship curricula.

Training for an international multicultural context

Currently the international inbound body remains insufficient despite the fact that procedures for mobility are well established. However, international guest speakers and international researchers contribute to the exposure of students to international experience. Outgoing and incoming mobility are carefully prepared and monitored by the department. Feedback is obtained from the concerned students.

Procedures for mobility are well-detailed (selection process; preparation for departure, study programmes, administrative and financial assistance, etc.). The programme has established 2 double degrees with recognised universities.

Sustainable development, social responsibility and ethics

Sustainable development, social responsibility, professional ethics are present in different courses, seminars, and studios, also related to current research. The department develops teaching adapted to the skills approach, i.e. using numerous situations that are ideally multidisciplinary and that place emphasis on student-centred teaching methods.

Educational engineering

A portion of the programme is delivered by professionals from the business world. The curriculum is based on training through experimentation in connection with professional teachers. The programme uses project-based teaching and relies heavily on concrete situations. Teaching provided during the programme uses different methods, including lecture tutorials (TD), practical work (TP), problem-based learning (PBL) and a well-justified and good relative balance of individual and group projects.

Student life

The department considers that student life is a fundamental element in education. The "archi week" and the student association "bructecture" contribute largely to this.

Student guidance and programme completion

The department checks the results obtained by the students and provides personalised guidance if necessary. The professional world considers that students have an important scientific basis, are open minded, are trained in critical thinking and are autonomous. However, they think that more ethics could be a good thing.

The method for assessing skills and learning outcomes is based on previously defined, publicly available criteria and involves businesses as much as possible. The conditions for awarding the degree are detailed in the academic regulations. The degree is awarded in compliance with laws and regulations, ensuring that each graduate has achieved the level of development expected at the end of the programme standards. The diploma supplement is issued to each graduate. It describes the individual pathway validated for each graduate.

Analysis summary – Master of Science in Architectural Engineering

Strengths:

- Courses taught in English;
- Strong influence of research in education;
- Numerous part-time professionals participating in the teaching;
- The programme is focused on sustainability;
- Critical thinking and open-mindedness acquired by students;
- Good gender balance;
- Great proximity of students and teachers;
- Enthusiasm of teachers and students;
- Double degree with TU Denmark and Politecnico Milano;
- Good follow-up of previous CTI guidelines for improvement.

Weaknesses:

- Frequency and usefulness of the meetings of the Course Council according to the students;
- Lack of official feedback processes towards students;
- Not enough attention for non-traditional subjects (e.g. timber, composite materials);
- Use of different systems, Canvas (VUB) and Université Virtuelle (ULB), for BRUFACE students, meaning the integration is not fully completed and creates uncertainties in the communication between professors and students.

Risks:

- No laboratory on concretisation of architectural elements;
- Low student number for a programme of this quality.

Opportunities:

- Being part of the new strategic plan of the faculty;
- Developing a specific lab for engineering architecture;
- High potential to further enhance the international development policy;
- Increasing added value by improving the internship process (subject's proposal, monitoring by the teaching staff);
- Teaching on intellectual property and deontology would make sense for the development of entrepreneurship.

Master of Science in Electrical Engineering

In initial engineering training under student status

General structure of the programme

The number of students in the programme was 79 in 2020-2021, which is a rather good number compared to other programmes. In 2021, 57% of the students were from Belgium, 37% from outside of Europe, and 6.2% from European countries outside Belgium.

In 2020 the programme graduated 29 people from Belgium and 17 foreign students, including 12 female students. This programme is proud of attracting so many female students in a field which is rather difficult in this respect, from 13.3% in 2016-2017 to 31.6 % in 2020-2021. This can be explained by the fact that many students from outside Belgium are from outside Europe.

This Electrical Engineering (EE) programme, which is rather popular and could be qualified as “generalist in electronics”, aims at training students in touch with the needs of society: electronics and IT have a strong impact on industry and more generally at an economic level. It is appreciated both by students and alumni. People who teach in this master’s programme are very devoted to their job, more mentors than teachers, and trust is established between students and teachers, as they spend a lot of time trying to help students progress.

It is a rather generalised master’s programme in its field because students get a theoretical and basic knowledge of both applications of electronics and information technology: from basic components to system and application levels.

This master’s programme will encounter a problem with respect to the number of teaching staff members from ULB because many of them are approaching retirement. There is also a problem with the lack of rooms (some classes take place on Saturdays) and a lack of assistants. Equipment is sufficient and of very good quality. The ambition of the staff is to grow “smartly”.

Development and monitoring of the educational project

Since the former CTI evaluation, the content has not changed much in terms of expected skills, so LOs and skills have not been updated, but the content and naming have been continuously updated, i.e. with Artificial Intelligence and Deep Learning topics for all students, according to recommendations of the professional field. To do so, a new professor has been recruited from industry.

Two new elective courses were also put in place on Cloud Artificial Intelligence Service and Cloud Machine Learning.

In option 1, two new courses for 10 ECTS appear with new teachers, replacing older ones:

- Nano and Electronic Devices and Technologies;
- High-frequency Electronics and Antennas.

In option 3 courses were also renamed to better match with the LOs approach and a new course for option 2 was added: Machine Learning and Big Data Processing; this course is now taken by 2/3 of the students in the class, which corresponds well with the current trend observed in the jobs of alumni.

Four of the professors are employed at least part time in the electronics industry. They teach core courses but are also in charge of specific aspects of the organisation.

There is a permanent representative from the professional field on the Course Council.

Professional field consultations (10 respondents) were also organised.

For the time being the professional field meetings are organised when useful, a more formal organisation would be a plus for the sake of quality.

Students also contribute to the development of programmes in very diverse ways. They are close to the teaching staff and when a problem appears it is immediately made known to the management of the programme.

Curriculum: programme outcomes and learning outcomes

The programme is correctly described on the website and in the documents produced by VUB, so it is accessible to everyone. Descriptions include learning outcomes (LO) and assessments. The first year covers a wide range of basic topics and in the practical work, a progress can be observed in the field covered from week to week. Transferable skills are considered as achieved as part of the regular technical programme during various assignments, as required by the professional field.

In the 3rd year of the bachelor's, 26 ECTS are dedicated to Electrical Engineering, then the first year of the master's contains the common core set of courses from components to system level. Bridge courses can be offered to students that do not have these basics.

In the second year, students must choose electives for 12 ECTS and one of 3 options (24 ECTS):

- Nano, Optoelectronics and Embedded Systems;
- Information and Communication Technology Systems;
- Measuring Modelling and Control.

The money received (upfront financing) has been used to improve the support of the foreign students, providing them with catch-up courses to bridge their shortcomings.

Programme implementation

Small sized student groups, an equilibrium between general knowledge and practical aspects is the rule in this master's programme.

The necessary progress in practical work seemed very well analysed.

On average, 38% students complete an internship. Lists of internships are presented by the teaching staff and each internship is tutored by a member of the teaching staff but very often students prefer to follow electives that are also interesting. Some students have already worked or work to pay for their studies, so they think they do not need internships. Non-European Economic Area students like internships because it stands out on their CV if they want to stay in Belgium after their studies.

Many projects are organised in connection with companies due to the fact that part of the teaching staff come from companies. The master's thesis is also very involved with start-up projects. The evaluation grid is common for all of the faculty's master thesis, while for projects each teaching staff member uses his/her own matrix.

First year master's students have the opportunity to coach the projects of first year bachelor students. A fablab is accessible at USquare.

The EE staff includes more than 140 PhD students, which means that these students interact on projects or exercises with the master's students.

Research activities, innovation and entrepreneurship training

Research is very present because the teaching staff members belong to industry research labs (IMEC, KMI, and Sony), in addition to those who work for state university laboratories. The subjects of the master's dissertations show a good balance of fundamental and applied subjects. Many spin-off (10) or start-up companies (4) have emerged through this master's programme to valorise PhD research. Students are very often enrolled in them in the framework of projects. The master's programme offers courses on entrepreneurship that explain the success of this activity, although these start-ups or spin-offs are very often created after the PhD thesis.

Training for an international multicultural context

The high ratio of non-European Economic Area students (37% in 2021-2022) largely contributes to the multiculturalism in the programme, which is less observed for European students who are in the Erasmus+ framework and stay only for 1 or 2 semesters.

However, there are too few outbound students (on average 3 students per year). A favourite destination is EPFL in Switzerland. For new-generation students, the potential of students who

could go abroad is 18, so the percentage of students who effectively go abroad is 16.7%, which is under the European goal of VUB of 20%.

Sustainable development, social responsibility and ethics

Sustainable development is embedded in many courses. For example: Microprocessor Architectures addresses the impact of data centres; Communication Channels integrates regulations at the national and international levels. Ethics on Artificial Intelligence is included in the courses through “Ethical implication of AI”. As oral assessment is carried out, discussion on these subjects can also be done during assessments.

Educational engineering

The COVID pandemic has made things evolve and a hybrid learning system is in place. The teaching staff tries to reduce dropout numbers by continuously monitoring students, especially foreign students.

Students suffer from too many platforms used by the teaching staff (up to 4 different ones).

Student guidance and programme completion

Students are mostly evaluated through oral assessments. This is time-consuming for the teaching staff but facilitates a close follow-up of students and a formative assessment. These assessments are sometimes called “interview evaluations”.

On average, 82.7% of students enrolled in courses pass each year. This varies depending on student gender: female students do better on average, also reflected by the fact that 1.5% of female students and 8.5% of male students do not complete the master’s programme.

The average number of years to succeed is 2.4 years.

If we look at the same subject from the perspective of geographical origin, 3.7 Belgium students did not finalise their studies in 2020-2021 while 11.3 non EEA students did the same. However, with the COVID pandemic and with the data of the previous years we can say it is not representative (the average of these data could be respectively 3% and 9%) which is less than in other programmes.

The quality and monitoring of students is real in this programme. The only big problem is the diversity of platforms used by the teaching staff.

Analysis summary – Master of Science in Electrical Engineering

Strengths:

- Trust is really developed between students and the teaching staff;
- Social impact of this master’s programme: approachable professors that have easy communication with students and make them feel welcome;
- Small groups;
- Social life on campus;
- Good programme evolution, well presented by the teaching staff;
- Well-balanced programme;
- The teaching staff is well in touch with industry (part-time teachers from industry);
- Oral assessment is well developed and appreciated both by students and staff;
- Positive effect of the COVID pandemic on hybrid learning;
- Visibility has improved thanks to successive managers.

Weaknesses:

- Exchanges between industry professionals and professors are too informal;
- The communication tools (platforms) and their use is not harmonized.

Risks:

- Programme resources: teaching and administrative staff members are overloaded with work;
- If a member of the teaching staff changes (due to retirement for example), informal aspects could change or disappear;
- Danger of using hybrid tools too often which reduces physical attendance.

Opportunities:

- Using the social impact of VUB to communicate and therefore increase the visibility of the master's programme;
- Maintain the formal level of feedback from students if a problem arises.

Master of Science in Applied Sciences and Engineering: Applied Computer Science

In initial engineering training under student status

General structure of the programme

The master's programme in Applied Computer Science (CS) is not a joint degree and is clearly aimed at recruiting foreign students.

The curriculum focuses on smart systems, specifically in the three areas of smart cities, digital health and digital earth. It addresses the range from hardware (sensors, actuators, devices and interconnection networks) to analysis and big data, using techniques such as parallel and distributed systems, artificial intelligence, and machine learning.

It consists of a set of compulsory courses, a specialisation in one of the three areas and various elective courses or internships.

A majority of students has an international background. They appear to be very happy with the programme and their performance matches that of local students. Students are admitted to the programme after passing an admission test and interview. This allows admission of students with a bachelor's degree in other subjects than computer science.

The number of students hovered around 25 per year between 2015 and 2019 and increased to 45 in 2020. The number of Belgian students has not been more than 10% and the fraction of non-EU students has consistently been above 70% with a peak of 89% in 2017/2018.

Only a third or fewer of the students are female which is not surprising given the gender imbalance in CS programmes across Europe.

Compared to the faculty as a whole, Applied Computer Science performs slightly less well: study efficiency is about 5% lower and the students take marginally longer to complete their studies. The dropout rate in Applied Computer Science is high at 16% (the faculty as a whole has a dropout rate of around 12% and the university as a whole a little over 8%).

However, given the very large number of international students in Applied Computer Science, the expert panel finds these numbers acceptable.

Development and monitoring of the educational project

The master's in Applied Computer Science is a well thought-out and up-to-date programme that satisfies a recognised need.

Curriculum: programme outcomes and learning outcomes

The programme aims to provide a broad education, mostly in data science and data engineering, but makes sure that students receive an all-round education, preparing them for a career in academia, industry or government.

The learning outcomes are well defined and detailed for each course and in a matrix at course unit level.

The two-year curriculum consists of four parts, a set of common, compulsory courses, a set of elective minors, a set of elective courses and a master's thesis project.

There is an optional internship, typically scheduled in the summer. The internship, regrettably, is not very popular with students, but this could, at least in part, be due to the COVID pandemic.

Programme implementation

The programme specifically targets students from different disciplines by bringing them up to date in the areas with which they are not familiar.

The interview-for-admission system implemented by the programme is very effective in creating lower dropout rates and in admitting students from very diverse backgrounds, which has really changed since the first CTI evaluation.

A course on programming in Java helps bachelor's graduates without a computer science background to get up to speed. As a result, the curriculum can be used by students from other universities in Belgium or abroad.

The programme depends somewhat on project work to teach students to work in groups, but there could be more of this.

50 % of the master's thesis' are related to projects proposed by the industry.

There is also little emphasis on internships which can be so useful to prepare students for a career in industry: not many students do an internship. Nevertheless, the expert panel recommends to get as many students as possible to do an internship outside the university itself. This provides valuable experience and often contacts for later job offers as well.

Research activities, innovation and entrepreneurship training

Many students continue on into a PhD programme. There is not much evidence of training for entrepreneurship.

Training for an international multicultural context

The programme is well set up for receiving international students. The attention given by staff to individual students contributes to their integration. The admission interview helps staff select motivated students and helps students to understand what will be expected of them.

Sustainable development, social responsibility and ethics

The faculty is looking to hire a professor specialising in security. The expert panel agrees that security is a very important aspect in any system involving big data and/or confidential data.

The course on soft skills that was introduced after the previous CTI assessment works well and is appreciated by students.

Educational engineering

The programme provides a reasonable balance between theory, project work, collaboration skills and presentations skills.

Student guidance and programme completion, employment

Given the small number of students, monitoring can still take place in a fairly informal setting. The evidence suggests that students are monitored quite intensively and problems are laid bare earlier rather than later. All this is good, but the programme should prepare for a future increase in student numbers.

The staff is mostly young and certainly enthusiastic; they maintain a good rapport with students; students find the staff helpful and easily accessible.

The alumni seem to find a place in the job market quite successfully.

Analysis summary - Master of Science in Applied Sciences and Engineering: Applied Computer Science

Strengths:

- Applied Computer Science presents a solid and balanced programme that is regularly updated;
- Enthusiastic students and teaching staff;
- The interview-based admission system is valuable not only for the faculty but also much appreciated by the students;
- Students and staff managed to create an effective teaching environment in spite of the COVID pandemic;
- The staff maintain extensive international contacts allowing, among others, students to be recruited effectively;
- A third of the students are female, which, among computer science programmes is excellent;
- The programme manages to accommodate motivated students with no or little computer science background from their bachelor's education;
- Sustainability plays a role in the taught courses.

Weaknesses:

- The fact that there are two computer science programmes at VUB, one in the Faculty of Sciences and one in the Faculty of Engineering, is confusing for prospective students.

Risks:

- For students with little or no computer science background, a substantial effort needs to be made to bring them up to speed;
- Social isolation is a risk for international students.

Opportunities:

- The internship programme could be beefed up and made more flexible;
- More master's theses could be linked to industry;
- A professor with a portfolio in security is being hired.

Master of Science in Photonics Engineering

In initial engineering training under student status

This ambitious and internationally oriented programme trains photonics specialists for the challenges of the 21st century. It is well balanced between scientific aspects, soft skills, innovation and entrepreneurship, and awareness of social and industrial needs. It stands out as one of the most attractive programmes in Europe in its field. This master's programme is attended by local students with a low enrolment rate.

The master's is currently organised in the form of two coordinated programmes, one taught 100% in English (on-campus and a partial online track) and the other partly in Dutch. The list of courses is very similar in the two programmes, only the language of the basic courses differs. The master's thesis in the Dutch programme is 24 ECTS and 30 ECTS in the English taught programme. This difference of 6 ECTS is due to more electives. However, the number of elective courses is limited in the Dutch-taught master's programme to meet the ratio between Dutch and English courses on offer.

General structure of the programme

Photonics engineering education in Flanders at master's level is jointly organised by two Universities, UGent and VUB, in the form of a long-term cooperation. The two institutions take turns in coordinating the programme, and this time the evaluation procedure is being conducted together with the VUB master's degrees.

Development and monitoring of the educational project

Photonic engineering employment in industrial R&D and in academia is dispersed topically and geographically but is abundant compared to the offer. To name a few sectors of activity, health, industrial sensing, climate monitoring, imaging for all kinds of applications, manufacturing from architecture down to nanotechnology, data visualisation, and aerospace are all in need of photonics engineers and scientists. Photonics skills are important for academic research as well. Clearly, the target job market is international to a large extent.

However, Belgium has a number of top international players and high-tech start-up companies in the photonics industry and local employment is not scarce. This programme therefore makes full sense.

A photonics Course Council supervises the operation of the course (together with the European master's programme) and monitors its changes. Students, alumni, guest faculty members from other faculties, and representatives from employers join the faculty in an annual meeting of the Course Council, all with voting rights to issue recommendations. Its tasks include among other things monitoring the workload, which has proved an effective way of getting feedback and implementing organisational changes.

Curriculum: programme outcomes and learning outcomes

The general motto is to "train game changers, who are going to solve some of the world's problems using photonics". A two-entry table provides information about the relationship between courses and learning outcomes. The ECTS system is used systematically and clearly explained.

The programme consists of photonics basic courses (taught in Dutch in the Dutch-taught programme but in English in the English taught programme), electives to be selected from a broad list of more advanced photonics courses, a multidisciplinary module to be selected from a broad variety of courses from other master's programmes, an elective industrial or academic internship and a final master's thesis. The programme concludes with an oral report on the master's thesis presented during a symposium attended by all students of the two master's years.

Teaching methods are diversified (see below). Guest lecturers are regularly invited to provide an industry perspective on how photonics is contributing changes to our world.

Programme implementation

The programme Course Council has taken the comments of the 2016 CTI evaluation into account quite effectively. The risk that photonics is perceived by current students and applicants as a narrow field that is strictly research oriented and disconnected from other branches of engineering has significantly decreased and the total enrolment in the English taught programme is on a positive slope, at a competitive level at the European scale. The Dutch taught programme enrolment, however, is at best stationary.

Internships are offered as an elective in two formats: short internships corresponding to 5 ECTS, and long internships corresponding to 10 ECTS.

Research activities, innovation and entrepreneurship training

Photonics is a research-intensive field of science and engineering. All students are offered the opportunity to get some experience in research tasks. A 6 ECTS elective on Photonics Research is offered. The master's thesis is systematically research oriented. Both the Photonics Research elective and the master's thesis focus on engineering research skills. Discussions with recent alumni has shown that while many students initially plan to go on to the job market after they

graduate with the master's degree, many change their minds as a result of their internship or master's thesis experience and continue towards a PhD.

Entrepreneurship is part of an elective minor during the second year. There, the students investigate a technical business development project, which is part of the European EUTOPIA consortium aimed at investigating options toward European Universities.

Training for an international multicultural context

For the English taught programme efforts are continuously being made to attract and to assist international students as well as to create double degree programmes with partner universities in various countries.

Outgoing mobility is optional but encouraged; however, students in the Fotonica programme are only moderately interested in this opportunity.

Sustainable development, social responsibility and ethics

The selection of soft skill courses, internship and master's thesis project put a large emphasis on ethics, social and societal relevance. Photonics is one valuable tool for monitoring the environment.

Educational engineering

The balance of teaching methods is good, with 30% theory, 35% laboratory training, 10% "21st century skills", and of course 25% master's thesis which goes together with a MOOC on an approved subject selected by the student.

Because laboratory courses are an important part of the programme in the first year, students in the "semi-online track", who followed the first year remotely, take those laboratory courses lumped together at the very beginning of the second academic year.

The pandemic lockdown periods were used as an opportunity to train both lecturers and students on how to best organise teaching remotely, a process which is still ongoing with the advice of education experts who can advise on best practices. A large set of video-recorded lectures now available to students is an appreciated by-product of the new teaching methods.

Student life

Student associations are active and provide a positive environment. The student associations are an asset for generating new applications, in particular from abroad. Some scholarships between 5,000€ and 10,000€ are available for selected applicants, but a larger number of them would increase the appeal of the programme.

Student guidance and programme completion

Faculty members post office hours open to the students. The two programme chairs, respectively at VUB and at UGent, make informal contacts with students who experience difficulties in their academic performance and follow up as required.

The evaluation system is well described. Internship evaluation criteria are stated clearly, and the internship advisor contributes to the evaluation, also for internships in industry.

Analysis summary - Master of Science in Photonics Engineering

Strengths:

- Multilingual/interuniversity programme leading to a joint degree in a multicultural context;
- Programme driven by top researchers and educators;
- Balanced high-quality, theory/praxis, and multidisciplinary course;
- Strong technology ecosystem and cleanroom environment;
- Human scale for interactions between academics, PhD students and master's students;
- Careful monitoring of quality;
- Good local employment opportunities;
- Emphasis on soft skills acquisition in addition to scientific outcomes;
- Introduction to industry perspective in the photonics field;
- Student associations actively support the programme.

Weaknesses:

- Too low inflow of local students because of the Dutch language.

Risks:

- Lack of attractiveness for the programme for local bachelor's students;
- Initial language difficulties of some students in the English taught programme;
- Need for student mentoring;
- Low awareness of the students of the course learning outcomes when a course starts;
- Competitive European market of higher education in photonics;
- Limited emphasis on societal demands, such as social engineer responsibility, sustainability, human needs in general.

Opportunities:

- Learn from the international students about how they use social media;
- Increase the part of system-oriented courses, internships, master's thesis projects;
- Keep improving skills related to the new online learning experience, mixing local students with those attending remotely if that is not incompatible with language barriers;
- Develop a strong alumni activity also including the more senior graduates;
- Use the EUTOPIA network to attract students from Europe;
- Offer an introduction to photonics for both international and local students.

European Master of Science in Photonics

In initial engineering training under student status

General structure of the programme

Photonics engineering education in Flanders at master's level is jointly organised by two Universities, UGent and VUB, in the form of a long-term cooperation. The two institutions take turns in coordinating the programme, and this time the evaluation procedure is being conducted together with the VUB master's degrees.

An Erasmus Mundus master's programme was launched over fifteen years ago and was an important step to create international visibility. This report evaluates the English taught European Master of Science programme.

Over the years, the English taught programme has been offered under two names: European Master of Science in Photonics and Master of Science in Photonic Engineering (see above), with only one of the two open to new students in a given academic year. The European master's will be phased out and frozen from 2023-2024 onwards after the current batch of 2nd year master's students has graduated. The Master of Science in Photonics Engineering will continue to train students in English.

Currently, new students, with an upward trend, including a large fraction of international students, enrol each year in Photonics at VUB.

Development and monitoring of the educational project

Photonic engineering employment in industrial R&D and in academia is dispersed topically and geographically but is abundant compared to the offer. To name a few sectors of activity, health, industrial sensing, climate monitoring, imaging for all kinds of applications, manufacturing from architecture down to nanotechnology, data visualisation, and aerospace are all in need of photonics engineers and scientists. Photonics skills are important for academic research as well. Clearly, the target job market is international to a large extent.

A photonics Course Council supervises the operation of the course and monitors its changes. Students, alumni, guest faculty members from other faculties, and representatives from employers join the faculty in an annual meeting of the Course council, all with voting rights to issue recommendations. Its tasks include among other things monitoring the workload, which has proved an effective way of getting feedback and implementing organisational changes.

Curriculum: programme outcomes and learning outcomes

The general motto is to “train game changers, who are going to solve some of the world’s problems using photonics”. A two-entry table provides information about the relationship between courses and learning outcomes. The ECTS system is used systematically and clearly explained.

The programme consists of photonics basic courses (taught in Dutch in the Dutch-taught programme but in English in the English taught programme), electives to be selected from a broad list of more advanced photonics courses, a multidisciplinary module to be selected from a broad variety of courses from other master’s programmes, an elective industrial or academic internship and a final master’s thesis. The programme concludes with an oral report on the master’s thesis presented during a symposium attended by all students of the two master’s years.

Teaching methods are diversified (see below). Guest lecturers are regularly invited to provide an industry perspective on how photonics is contributing changes to our world.

Programme implementation

The programme course council has taken the comments of the 2016 CTI evaluation into account quite effectively. The risk that photonics is perceived by current students and applicants as a narrow field that is strictly research oriented and disconnected from other branches of engineering has significantly decreased and the enrolment is on a positive slope, at a competitive level at the European scale.

Internships are offered as an elective in two formats: short internships corresponding to 5 ECTS, and long internships corresponding to 10 ECTS.

Research activities, innovation and entrepreneurship training

Photonics is a research-intensive field of science and engineering. All students are offered the opportunity to get some experience in research tasks. A 6 ECTS elective on Photonics Research is offered. The master’s thesis is systematically research oriented. Both the Photonics Research elective and the master’s thesis focus on engineering research skills. The discussion with recent alumni has shown that while many students initially plan to go on to the job market after they graduate with the master’s degree, many change their minds as a result of their internship or master’s thesis experience and continue towards a PhD.

Entrepreneurship is part of an elective minor during the second year. There, the students investigate a technical business development project, which is part of the European EUTOPIA consortium aimed at investigating options toward European Universities.

Training for an international multicultural context

Both in Gent and in Brussels, members of the faculties' administrative and technical staff appointed as programme officers assist international students in administrative matters as well as in getting around in their new living environment.

In addition to VUB participating in the TIME network of international exchanges, a set of double degree programmes have been introduced with partner universities in the Far East, in Russia and in South America.

Significant efforts have been put into screening the international student applications, involving the photonics faculty and the programme officers. The entire faculty provides support on cultural events and study path guidance to new students.

Outgoing mobility is compulsory.

Sustainable development, social responsibility and ethics

The selection of soft skill courses, the internship and master's thesis project put a large emphasis on ethics, social and societal relevance. Photonics is a valuable tool for monitoring the environment.

Educational engineering

The balance of teaching methods is good, with 30% theory, 35% laboratory training, 10% "21st century skills", and of course 25% master's thesis which goes together with a MOOC on an approved subject selected by the student.

A large set of video-recorded lectures now available to students is an appreciated by-product of the new teaching methods.

Student life

Student associations are active and provide a positive environment. The student associations are an asset for generating new applications, in particular from abroad. Some scholarships between €5,000 and €10,000 are available for selected applicants, but a larger number of them would increase the appeal of the programme.

Student guidance and programme completion

Faculty members post office hours open to the students. The two programme officers, respectively at VUB and at UGent, make informal contacts with students who experience difficulties in their academic performance and follow up as required.

The evaluation system is well described. Internship evaluation criteria are stated clearly, and the internship advisor contributes to the evaluation, also for internships in industry.

Analysis summary – European Master of Science in Photonics

Strengths:

- International multicultural/multilingual/interuniversity programme leading to a joint degree;
- Programme driven by top researchers and educators;
- Balanced high-quality, theory/praxis, and multidisciplinary course;
- Strong technology ecosystem and cleanroom environment;
- Human scale for interactions between academics, PhD students and master's students;
- Careful monitoring of quality;
- New perspectives offered by the "semi-digital track";
- Good local employment opportunities;
- Emphasis on soft skills acquisition in addition to scientific outcomes;
- Introduction to industry perspective in the photonics field;
- Student associations actively support the programme.

Weaknesses:

- Low inflow of international students from EU;
- Low inflow of local students.

Risks:

- Existing competitive environment among master's programmes both at VUB and UGent;
- International competition to attract students from abroad;
- Competitive European market of higher education in photonics;
- Lack of attractiveness for the programme for local bachelor's students;
- Initial language difficulties of some students;
- Need for student mentoring;
- Low awareness of the students of the course learning outcomes when a course starts;
- Low international incoming and outgoing student mobility and need for funding apart from the Erasmus+ programme;
- Limited emphasis on societal demands, such as social engineer responsibility, sustainability, human needs in general.

Opportunities:

- Learn from the international students about how they use social media;
- Increase the part of system-oriented courses, internships, master's thesis projects;
- Keep improving skills related to the new online learning experience, mixing local students with those attending remotely;
- Develop a strong alumni activity also including the more senior graduates;
- Use the EUTOPIA network to attract students from Europe;
- Offer an introduction to photonics for both for international and local students.

Engineering student recruitment

In Belgium, access to bachelor's degrees is not subject to an entrance exam by law. A mandatory non-binding test exists but students who do not pass the test can still enter the bachelor's programme. They then have to pass additional tests in mathematics, chemistry and Dutch at the start of the first year. The university has put in place catch-up courses (some online) but they are not always followed by the students who would need them.

Thus, the selection strategy is imposed by the Flemish Community, and even if this subject is discussed between universities, only a decree could make this change. This is a very sensitive problem in Flanders because some people think that the test being non-binding led high schools to reduce the level in mathematics, physics and chemistry of their students, while the test remains binding for studies in medical studies. Furthermore, some student unions do not want the test to become mandatory as in the past.

The students applying for a BRUFACE master's programme are selected by both VUB and ULB. The programme is taught in English, which attracts many international students.

The admission process is described online for each programme on the VUB or BRUFACE website. For the master's degrees, the Admission Committees approve the application of international students. For each programme, the Committee selects the students with a background that fits the programme, then interviews are organised. This has greatly progressed since the previous evaluation procedure by CTI.

The inflow of international students is limited each year to ensure the quality of the programme. In order to secure a high quality of incoming international students, the faculty implemented a more robust process including the screening of candidates and then interviewing all accepted students using a common set of technical questions in order to ascertain the scientific level of the student.

The questions are decided by the Programme Council, and results are saved and analysed. Some student mentoring is offered by professors after admission (coaching sessions: one teaching staff members coaches 5 to 6 students).

Graduating from high school is the only requirement in Belgium to study at an engineering school. Students with a bachelor's degree can apply for a master's degree at VUB in the BRUFACE initiative or for another programme.

Graduate students with a bachelor's degree from a European Economic Area or international university can also be selected if their degree fits the prerequisites of the master's programme.

For admission to the bachelor's programmes VUB organises, with the other Flemish engineering faculties, a non-mandatory test for students (mathematics and physics). Those who fail the test can attend specific courses in order to catch up.

Most students are from Brussels, or at least from Belgium. Due to the fact that all high school students can enter the bachelor's programmes, VUB cannot ensure diversity in the bachelor's programmes. No international students apply because courses are taught in Dutch. Students with disabilities can ask the university for personalised services.

Analysis summary – Engineering student recruitment

Strengths:

- Additional and catch-up courses for those who failed the entrance test;
- A strong procedure including interviews for the recruitment of foreign students.

Weaknesses:

- Low number of Belgian students entering the bachelor's programmes.

Risks:

- A faculty with mainly international non-European Economic Area students highly depends on pandemics or geo-political issues;
- Change in regional policy for subsidising non-European Economic Area students.

Opportunities:

- International partnerships;
- The plan for an English taught bachelor's programme in engineering.

Employment of engineering graduates

1.2 and 1.5 % of graduates remain unemployed respectively two and one year after graduation. This is to be compared with the average unemployment rates in Belgium which are for the same period 3.1 and 4.3%.

50% of graduate engineers in 2019 had already a signed contract in July 2019 and 85% in September 2019.

There is no problem for finding a job as an engineer in Belgium.

From 2018, the median gross monthly starting salary was €2900 euros, to €7484 at the end of career.

Employers are consulted during work field inquiry sessions. However, during the exchanges of the expert panel with employers, not all employers were on the same page concerning the need to learn soft skills at university, some of them arguing the fact that it was necessary that students acquire as many technical skills as possible. Therefore, the way that some programmes integrate sustainability into their core courses seems well fitted. However, some employers insisted on developing the ethical vision of engineers, and others on the need for graduates to have notions in law, finance, and management.

The programmes on the website are described with examples of carrier paths.

Study Guidance advises students on making the right choice for an underlying professional career path.

The VUB career centre is not sufficiently used by students. Students the expert panel met during the site visit did not even know that it exists. They prefer seeking advice during Job Days where they meet companies or through personal connections they keep with alumni.

Every 5 years, VUB organises an alumni survey. The last one was carried out in 2021. This survey is also an employment satisfaction survey. The response rate for French speaking alumni does not seem very high, with only 71 graduates responding, most of which were from electromechanical engineering.

It appears that the channel most used to find a job was the faculty job fair.

The work field enquiries complete the exchanges with employers.

Two yearly publications on salaries are published by the association of engineers ie-net (for experienced engineers and for graduates). The university consults them to be informed of trends.

The Flemish government job mediation agency also publishes reliable information on these subjects and the university takes them into account.

Alumni work together with students for the yearly organisation of the job fair through the Executive Council of the Association of Engineering Alumni of VUB (BrEA). They are represented on the Faculty Council.

Analysis summary - Employment of engineering graduates

Strengths:

- Belgium has a high employment rate;
- Even non-European Economic Area students easily find a job;
- Organisation of a job fair by alumni, students and faculty.

Weaknesses:

- N./A.

Risks:

- N./A.

Opportunities:

- Make the Career Centre better known to students.

Overall summary of the evaluation

The VUB has an excellent understanding of the challenges that future engineers will have to face. Since the previous evaluation procedure, the Faculty of Engineering has progressed significantly on its processes and on the programmes that are very well monitored.

All stakeholders appreciate the small size student groups and the culture of trust that exists in each programme.

The quality of recruitment of foreign students has also improved thanks to robust procedures. However, the risk of having only foreign students in the master's programmes in the future should not be overlooked. It is therefore necessary that the Faculty of Engineering increases the attractiveness of its programmes for local students starting at the bachelor's level. The plan for a bachelor's programme taught in English seems one of the best ways to counterbalance the trend. The faculty has perfectly used the COVID pandemic period to improve its online teaching and offers blended learning opportunities.

The BRUFACE programmes as well as joint masters' degrees have also improved since the previous evaluation procedure. However, an effort remains to be made on tools available to students and staff. A specific common database used for the programme management and external evaluation procedures is needed.

Overall analysis summary

Strengths:

- Pleasant living and working conditions on campus;
- The university has a specific and positive image: small and human;
- Panel attendees willing to communicate and very open to discussion;
- Improvements have been made to improve the procedure to select international students;
- Best practices in teaching shared at faculty level;
- The BRUFACE programmes are well designed;
- VUB and ULB are in the process of aligning procedures;
- The training of the teaching staff is of good quality;
- Good cooperation with other Belgian universities;
- Excellent facilities in laboratories with a great variety of research and innovation projects.

Weaknesses:

- Different platforms for the students in the BRUFACE programmes;
- BRUFACE programmes still need to improve their communication;
- The faculty's human resources have not increased;
- The response rate of students to satisfaction surveys is too low.

Risks:

- Low number of recruitments for bachelor's students;
- Dropout rates during the bachelor's programmes;
- Feedback from companies are not formalised enough;
- Most of the teaching assistants are paid on research and innovation grants or project funds;
- Heavy student workload.

Opportunities:

- The plan for a Bachelor in Engineering taught in English;
- Professional Advisory Councils could be a plus;
- Collaborations with communities in Brussels;
- Eutopia could increase incoming EU students.

- End of the evaluation report -