FINNISH EDUCATION
EVALUATION CENTRE

ACCREDITATION OF THE ENGINEERING DEGREE PROGRAMMES IN INFORMATION AND COMMUNICATION TECHNOLOGY AT THE UNIVERSITY OF TURKU

Jukka Suomela | Kati Isoaho | Peeter Normak
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Description of the accreditation process and of the degree programmes

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1.1 Aim of the pilot accreditations

The aim of FINEEC's Engineering Programme Accreditations is to support the enhancement of quality in engineering degree programmes and to provide higher education institutions with the means of deciding whether an engineering degree programme provides its graduates with the academic qualifications necessary for a career in the engineering profession. FINEEC's accreditation concept is based on the international EUR-ACE standard owned by the European Network for the Accreditation of the Engineering Education (ENAEE). Accreditation assesses the way an engineering degree programme is planned, delivered and developed to ensure that the students reach the programme outcomes and how the programme outcomes align with the reference programme outcomes set in the FINEEC Engineering Programme Accreditations manual. The reference programme outcomes describe the knowledge, skills and competencies that engineering students should have acquired by the time they have completed a degree programme in engineering. The reference programme outcomes are described separately for the Bachelor's degree programmes and for the Master's degree programmes. The accreditation evaluates the extent to which the set standards for programme's planning, implementation, resources and quality management are met.

FINEEC has carried out engineering degree programme accreditations since 2014 at the Finnish universities of applied sciences. FINEEC is authorized by ENAEE to award the EUR-ACE labels to the 4-year degree programmes of 240 ECTS. To extend its mandate to the 3-year and 2-year degree programmes, FINEEC carries out pilot accreditations in 2022–2023. This accreditation is one of these pilot accreditations. The aim of the extension is to be able to better serve the whole higher education sector in Finland, along with the universities and universities of applied sciences.

1.2 Degree programmes in Information and Communication Technology

This accreditation covers two degree programmes in the field of engineering: The Bachelor´s degree programme in Information and Communication Technology and Master´s degree programme in Information and Communication Technology. Three tracks of the Master's degree programme have been included in the accreditation as follows:

- Software Engineering (SE)
- Smart Systems (SS)
- Communication and Cyber Security Engineering (CSE)

The degree programmes belong to the University of Turku and its Faculty of Technology as well as Department of Computing. The degree programmes lead to a Bachelor of Science (Tech) degree and a Master of Science (Tech) degree. The language of instruction is Finnish in the Bachelor's degree programme and both Finnish and English in the Master's degree programme. The Bachelor's degree programme consists of 180 ECTS and intended study time for full-time studies is three years. The Master's degree programme consists of 120 ECTS and intended study time for full-time studies is two years.

2022 intake for the combination of the Bachelor´s degree programme and the Master´s degree programme is 120 students and directly to the Master´s degree programme 30 students.

1.3 The accreditation process

The accreditation was conducted in accordance with the principles set in the *FINEEC standards and procedures for engineering programme accreditation* document. The schedule of the accreditation was the following:

- The accreditation team was appointed by the FINEEC Committee for Engineering Education on 12th April 2022.
- University of Turku submitted the self-evaluation report on 8th April 2022.
- A site visit to the degree programmes was conducted on 10–11 May 2022. The programme of the visit is given in table 1.
- Decision making meeting of FINEEC Committee for Engineering Education on 8 September 2022.

TABLE 1. Site visit programme

Site visit programme			
Tuesday 10th May 2022		***Wednesday 11th May 2022***	
9.00–10.00	Interview with the management of the UTU and the degree programmes under review 8 persons	09.00–9.50 8 persons	Interview with the external stakeholders
10.15–11.15	(a parallel session) Interview with the academic staff, Master´s degree programme 8 persons	10.05–10.55	Interview with the students of the Bachelor´s degree programme 6 persons
10.15–11.15	(a parallel session) Interview with the academic staff, Bachelor´s degree programme 8 persons	11.10–12.00	Interview with the alumni of the degree programmes 8 persons
11.30–12.20	Interview with the support services staff 8 persons	13.00–13.50	Interview with the Master´s degree programme students 6 persons
13.20–14.20	Academic staff presented examples on the teaching and assessment methods (demos), Bachelor´s degree programme 8 persons	14.00–15.00	Academic staff presented examples on the teaching and assessment methods (demos), Master´s degree programme 4 persons
14.45–17.30	Facilities tour at UTU	15.00–16.30	Accreditation team´s meeting
17.30–18.45	Accreditation team´s meeting	16.45–17.30	Initial feedback for the UTU and the degree programmes´ management

1.4 The accreditation team

Team chair:

- Associate professor **Jukka Suomela**, Department of Computer Science, Aalto University (Finland)

Team members:

- Director, Professor and Head of the Applied Informatics Academic direction **Peeter Normak**, School of Digital Technologies, Tallinn University (Estonia)
- PhD student **Elena Stefancova**, Comenius University in Bratislava (Slovakia)
- Executive Consultant **Petri Takala**, Data Analytics Gofore Ltd. (Finland)

Senior Evaluation Advisor **Kati Isoaho** from FINEEC acted as a Project Manager for the accreditations.

1.5 Evidence used in the accreditation

Self-evaluation report, along with the following appendices:

1. Description: Stakeholder engagement and analysis of stakeholder needs in curriculum development.
2. Curricula analysis: Programme learning outcomes mapped against the FINEEC reference programme outcomes for both degree programmes along with the three tracks of the Master´s degree programme.
3. Visual demonstration on how the defined degree programme level learning outcomes align with the FINEEC reference programme level learning outcomes.
4. Supporting documents that define the curriculum development process and show the curriculum development work in practice.
5. Description: implementation of teaching and learning in the Bachelor's degree programme.
6. Description: implementation of teaching and learning in the Master's degree programme.
7. Bibliometric analysis and Citation analysis, Department of Computing.
8. Curriculum Vitae documents of key teaching personnel in the degree programmes.
9. Information on the basic funding and supplementary funding, Department of Computing.
10. Quality Manual of the University of Turku 2022.
11. The main documents for student feedback, including the feedback collection forms and evidence on feedback analysis.
12. Presentation on the results of the Finnish Bachelor Graduate survey 2021, Department of Computing.
13. TEK Graduate Survey materials.
14. Results of Career Follow-Up Survey 2016–2020, Master´s degree programme and its tracks.
15. Recent Admission statistics 2017–2021.
16. Examples of study administrative follow up reports.
17. Report: RAE2015 of the University of Turku. Peer-evaluation report. Department of Information Technology.

- Accreditation team had access to the UTU intranet during the review process.
- Information gathered during the site visit within the interviews with the UTU and the degree programme management, academic staff, support services staff, current students, alumni as well as key stakeholders. Academic staff and students were interviewed separately for the Bachelor´s degree programme and Master´s degree programme.
- Information gathered in the teaching demo sessions arranged during the site-visit. Sessions covered both degree programmes under review.
- The facilities tour on the UTU and the degree programme facilities, including classrooms, IT classrooms, self-study spaces, libraries, laboratories as well as premises reserved for the student associations.

- Evidence gathered by the degree programmes for the electronic evidence room, which included admission materials, course material, thesis works, project works and examples of course feedback, material on the cooperation with the industry stakeholders as well as material on the degree programme staff´s research publications. Furthermore, the material included teaching activity reports of both degree programmes under review along with the examples of teaching and assessment methods. The material covered all the FINEEC reference programme outcome categories. The evidence room was arranged as a Moodle software workspace. The accreditation team had access to the evidence room starting from 29Th April 2022 as well as after the site visit by the end of August 2022.

Accreditation team requested the following extra materials: job descriptions of the degree programme heads and examples of the minutes of the curriculum steering groups as well as degree programme steering groups.

2

Evaluation of the fulfilment of the accreditation standards

2

2.1 Planning of the programme

Standard 1: The programme aims, which describe the educational task and purpose of the programme, are consistent with the mission of the higher education institution and reflect the identified needs of employers and other stakeholders.

Both the Bachelor’ s degree programme and the Master’ s degree programme aim at training experts for the needs of future business and society. The aims of the degree programmes put emphasis on a solid scientific foundation acquired in the multidisciplinary university. The degree programmes have a clear engineering profile—the goal is that the graduates have practical problem-solving and product-development skills.

The overall aims of the degree programmes are described in a clear manner, and in language that is also understandable for prospective students and external stakeholders. However, the key differences between the aims of the Bachelor’s degree programme and the Master’s degree programme, and the independent role of the Bachelor’s degree programme by itself are not equally clear.

The self-evaluation report describes the Bachelor’s degree programme’s aims as follows:

”The overall aim and objective of the degree programme is to provide a sufficient polytechnic foundation for students to continue in their chosen degree programme as well as in other applicable Master’s degree programmes, to provide a theoretical and technological foundation for working life and to provide competence for lifelong learning in working life. The general learning objectives of the programme have been defined as follows. All students graduating from the programme:

- *Have a strong and wide-ranging theoretical foundation in information technology and are able to apply it in practice.*

- *Are able to perceive and identify problems specific to the engineering profession. Able to define, design and implement solutions to problems specific to the engineering profession, taking into account realistic constraints.*
- *Are able to work in a group and able to interact effectively orally and in writing. Are able to acquire, evaluate and critically process the information they need and apply it in practice in engineering work.*
- *Are able to develop their skills and make active choices in building a professional profile.*
- *Understand professional and ethical responsibilities in their work.*
- *Understand the importance of research and technological development for the development of society."*

The aims of the Master´s degree programme are described as follows:

"The goal of ICT is to train MSc (Tech) graduates for the needs of future business and society. The versatile major subject in ICT provides good opportunities for this. The University of Turku's MSc(Tech) degree programme in ICT is based on the solid scientific base of a multidisciplinary university and is profiled in the development of content, services and products for the information society. The graduate is an ICT expert with good skills in application of theory into practice and problem-solving, as well as good communication skills and the ability to develop innovative products and services in key areas of the information society. In the degree, you can choose (2022 onwards) to specialize in data analytics, software engineering, communication and cybersecurity engineering, or smart systems."

Indeed, the Bachelor's degree programme seems to be largely perceived as laying the groundwork for studies in the Master's degree programme, as the *first* high-level aim of the Bachelor's degree programme is "to provide a sufficient polytechnic foundation for students to continue in their chosen degree programme as well as in other applicable Master's degree programmes". In the interviews with the teachers of the Bachelor's degree programme, many teachers also mention the preparation of the students for the Master's studies as the *first* aim of the programme. Also, in the "information about studies" page in the study guides of the Bachelor's degree program, the first sentence actually refers to training Master-level graduates. It is not always clear which descriptions of the aims refer to the knowledge and skills acquired already during Bachelor-level studies, and which aims refer the two degree programmes put together—are Bachelor-level graduates already expected to be capable engineers ready to tackle the future challenges of businesses and society, and if so, what is then the added value of the Master's degree programme? A lot of this confusion is of course understandable, given the history of higher education in Finland (especially pre-Bologna) and the local practice of admitting students directly for both Bachelor and Master-level studies. Nevertheless, the accreditation team sees that the Bachelor's degree programme should also be able to stand on its own, and have a clear aim that is distinct from the Master's degree programme.

The self-evaluation report describes in great detail the connections between the degree programmes and the strategic research and education profiles of the university. The University of Turku has the following strategic research and education profiles: A1. Biodiversity and sustainability; A2. Future technologies and digital society; A3. Cultural memory and social change; A4. Children, young people and learning; A5. Health, diagnostics and drug development and A6. Sea and maritime studies. The high-level aims are well-aligned with the mission and strategy of the University of Turku—in particular, the opportunities provided by the multidisciplinary university are prominently highlighted in the aims of the degree programmes.

All educational affairs of the department, including curriculum development, are discussed, prepared and planned in the Educational Development working group lead by the vice head of the department (responsible for education) and consisting of professors, other academic staff and student representatives as well as administrative staff. All received and obtained stakeholder input and feedback is brought to this group for discussion and as input for development processes including the development of degree programme level aims. A similar working group also operates at the faculty level. This group consists of the vice dean of the faculty, (responsible for education), all vice heads of departments (responsible for education) and student representatives as well as administrative staff. The input and feedback from stakeholders at the faculty level is discussed in this group and, based on the interviews, guidelines are given to the departments concerning curriculum development at the faculty level. The input and feedback are disseminated to the department level working group from the faculty level group.

Based on the self-evaluation report as well as interviews with the management, teaching staff, alumni and external stakeholders, the degree programmes are developed in close collaboration with employers and other stakeholders. The self-evaluation report has identified (1) internal stakeholders, (2) financial stakeholders, (3) external stakeholders and (4) main employer groups.

The degree programmes are part of well-established and active university networks, and it is evident that there is great networking and cooperation potential with external stakeholders especially in the Turku region, and the self-evaluation report and its appendices provide plenty of evidence of active collaboration with the key stakeholders and of systematic information gathering and analysis of their needs.

As explained in the self-evaluation report, at the time of the curricula reform of 2019, the content and focus of the degree programmes were thoroughly evaluated. In this work the needs of the main industries and other stakeholders in Southwest Finland were evaluated and mirrored towards the degree programme aims. At the same time the educational portfolios of other technical universities in the field of ICT were evaluated and the profile of the university´s own educational portfolio fine-tuned to focus on the department´s research strengths and educational competence. The work formed the basis for the development work for the 2020–2022 curricula in the faculty.

The degree programmes are planned in an internal curriculum-planning group which should have an external advisory group consisting of representatives from different stakeholders. The Bachelor’s degree and all three Master’s degree tracks have dedicated advisory groups.

In addition to staff members and external stakeholders, student representatives appointed by student associations take part in planning the curriculum.

The high-level aims of the degree programmes are also well aligned with the needs of the stakeholders (with the above caveat related to the independent role of the Bachelor's degree). However, as we will discuss in Section 2.2 in more detail, there seems to be a disparity between the work-life skills that the stakeholders would like to see in the graduates and what the degree programmes delivers—this part of the feedback loop between stakeholder needs, programme planning, and programme implementation is apparently not working perfectly.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 1 conditionally.

Based on the team's assessment, the Master´s degree programme meets Standard 1 fully.

Standard 2: The programme learning outcomes, which describe the knowledge, understanding, skills and abilities that the programme enables graduates to demonstrate, are consistent with the programme aims, with relevant national qualifications frameworks (if applicable) and with the FINEEC reference programme learning outcomes.

Bachelor´s degree programme

The degree programme has 24 learning outcomes that cover:

1. knowledge of the foundations of ICT and the ability to apply it in practice,
2. problem-solving skills,
3. skills related to work life, teamwork, project management, and career development,
4. communication and information retrieval skills,
5. understanding of ethical and societal issues, and
6. more specific technical skills needed in the ICT field (e.g., programming skills).

The list of learning outcomes is relatively long, and there is some repetition (e.g., *"Has a strong and wide-ranging theoretical foundation in information technology and is able to apply it in practice"* vs. *"Is able to apply learned theoretical things in practical tasks."*), but the list captures the essence of the skillset of an ICT engineer, and it is also well-aligned with the aims of the degree programme and also with the needs of the stakeholders.

However, there is one main gap between the learning outcomes and the FINEEC reference programme learning outcomes: non-technical multidisciplinary competences. While the programme-level learning outcomes explicitly mention ethical responsibilities and the connection with the needs of the society, issues related to the environment and health are not mentioned at all.

This is a notable omission also given the fact that the aims of the degree programme mention the foundation that the students acquire in the multidisciplinary university. As areas such as ”biodiversity and sustainability” and ”health, diagnostics, and drug development” are among the strategic profiles of the University of Turku, this also seems like a missed opportunity.

Other areas of the FINEEC reference programme outcomes are covered in the programme learning outcomes of the Bachelor’s degree programme.

Master´s degree programme

Each of the Master´s degree programme’s tracks under review has got its own programme learning outcomes.

In the *Software Engineering* track, there are 10 learning outcomes, most of which focus on technical skills and knowledge related to software engineering. However, there are also learning outcomes related to understanding business processes, teamwork, project management, security, and privacy. The learning outcomes are relevant and consistent with the aims of the programme. However, in comparison with the FINEEC reference programme learning outcomes, there are only a few learning outcomes related to information retrieval and multidisciplinary competences. ”Ability to work in a multidisciplinary team” is mentioned, but e.g., topics such as health, the environment, society, and ethics are not explicitly covered in the learning outcomes.

In the *Smart Systems* track, there are 8 learning outcomes, 3 of which are related to the technical skills of this specific area, while most of the learning outcomes are more general, covering teamwork, problem solving, communication, and career development. Again, in comparison with the FINEEC reference programme outcomes, information retrieval and non-technical multidisciplinary competences are lacking.

In the *Communication and Cyber Security Engineering* track, there are 13 learning outcomes, 8 of which are related to the technical skills of this specific area, and 5 of which cover problem-solving, teamwork, project management, and communication skills. Also in this track, information retrieval and non-technical multidisciplinary competences are lacking. A particularly notable omission is that ethical issues are not explicitly mentioned.

Overall, the learning outcomes of the three tracks are not particularly well-aligned with each other, and they appear to be developed independently. The broader skills that are not specific to a particular track are phrased differently, and it is not clear to the reader if the differences between the tracks are intentional (for example, the Software Engineering track mentions leadership skills, the Communication and Cyber Security Engineering track mentions project management skills, and the Smart Systems mentions neither of these explicitly).

The accreditation team recommends that the learning outcomes of the three tracks are unified so that the students and stakeholders can clearly see (1) what the broader learning outcomes of the Master's degree programme common to all the tracks are, and (2) what the specific learning outcomes particular to each track are.

The university has defined the degree programmes to belong to levels 6 and 7 of the Finnish national qualification framework (FinnNQF). As there are no national field-specific qualification frameworks in Finland, the degree programmes are designed to follow the standards of the international CDIO framework. The CDIO Initiative is an educational framework for engineering education. The CDIO framework highlights engineering fundamentals set in the context of Conceiving — Designing — Implementing — Operating (CDIO) real-world systems and products. The accreditation team commends this practice and considers it a useful tool for the improvement of education in both degree programmes.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 2 conditionally.

Based on the team's assessment, the Master´s degree programme meets Standard 2 conditionally.

Standard 3: The course level learning outcomes, including thesis work and possible practical training, aggregate to the programme's learning outcomes.

Bachelor´s degree programme

The Bachelor´s degree consist of the following parts: at least 55 credits of joint basic studies belonging to the degree programme, at least 88 credits of major subject studies, a Bachelor's thesis of 8 credits (included in the minimum scope of the major subject), other studies including optional studies, 12 credits of language and communication studies, and at least 25 credits of minor subject studies from at least one subject. Multidisciplinary modules described in the curriculum are also accepted as minor subjects.

While the descriptions of the learning outcomes of individual courses are more detailed, the descriptions of the learning outcomes of the modules are short and sometimes do not harmonise with the learning outcomes of the courses in the module. For example, the learning outcome of the Mathematics module (19 ECTS) consisting of four courses is formulated in just one sentence.

Especially the courses in the Mathematics and Physics modules could be linked better with applications and topics related to the ICT field. In particular, the role of the four-course physics module in achieving learning outcomes of the study programme seems relatively vague.

The knowledge and understanding related to the fundamentals of the ICT field is in general covered well in the course-level learning outcomes. The coverage of mathematics is typical, both in volume (19 ECTS) and in choice of topics (e.g., basic algebraic structures, discrete mathematics, linear algebra, complex numbers, differential and integral calculus, probabilities and statistics, and Fourier analysis). In terms of building the foundations, one of the strengths of the degree programme is the amount of physics in the programme (4 courses, 16 ECTS credits in total)—this is more than what one would expect from a Bachelor-level graduate in ICT, and this could be a competitive advantage also in the job market.

Some of the programme-level learning outcomes related to knowledge and understanding are broad and covered in numerous courses. For example, according the self-evaluation report, *all* compulsory Bachelor-level courses (except the thesis) contribute to learning outcome 1, "Has a strong and wide-ranging theoretical foundation in information technology and is able to apply it in practice".

However, some of the learning outcomes are more fine-grained and more specific to the ICT area, and of particular interest here are learning outcomes 7–9 that are related to knowledge and skills related to software development, broadly interpreted. Among the compulsory courses that are common for both the Smart Systems track students and the Software Engineering track students there are:

- no compulsory courses related to learning outcome 7 ("Knows software engineering methods, tools and development processes and understands the importance of parts of agile development processes and is able to apply them as part of a development team")
- 6 courses related to learning outcome 8 ("Has good programming skills")
- 3 courses related to learning outcome 9 ("Knows the implementation methods of a wide range of software engineering solutions and is able to apply them to a wide range of performance platforms (e.g., distributed systems, mobile platforms, web)").

In the Smart Systems track there is one additional course related to learning outcome 8, but no courses related to learning outcomes 7 and 9, while in the Software Engineering track there are 4 track-specific courses, all of which contribute to learning outcomes 7, 8, and 9. The two tracks have different focuses, but it is somewhat concerning that the Smart Systems track students do not seem to have any courses related to programme-level learning outcome 7.

Engineering practise: Based on the self-evaluation report, on the course descriptions, and evidence presented during the site-visit, it can be concluded that the degree programme provides students with the necessary knowledge and skills. Five of the 24 learning outcomes (learning outcomes 2, 8, 10, 13, 16) deal with design competences and six (1, 3, 7, 9, 17, 18) with the development of practical competences. Some issues are discussed under Standard 8.

For example, the accreditation team considers that concerning design and practice, compliance with FINEEC Reference Learning Outcome ”practical skills for realizing complex engineering designs” is questionable and it is recommended to enhance this aim at the time of the next curriculum update.

The learning outcomes of the degree programme related to the engineering practise are adequate and comprehensive. The degree programme includes strong mathematics and physics basic courses which support the understanding of analysis in technical problems. In the general programme description, business skills are highlighted and deeper study of the curriculum highlights that the course is related to the basics of business terminology and business administration—the internal view of a company. There was a little evidence of market opportunities, customer value identification or non-technical analytical learning design.

For multidisciplinary competences there are two key learning outcomes related to non-technical multidisciplinary competences. One of them is *”Understands the importance of research and technological development for the development of society”*. In the analysis of the alignment of courses and learning outcomes there are four courses that are supposed to cover this area, ”Foundations of Artificial Intelligence”, ”Methods of Artificial Intelligence”, ”Embedded Microprocessor Systems”, and ”Bachelor’s thesis and seminar”, but only one of these courses seems to explicitly mention societal issues in their learning outcomes. Another one is *”Understands professional and ethical responsibilities in their work”*. This is also covered by four courses, ”Introduction to Engineering”, ”Digitalisation and Cyber Security”, ”Foundations of Artificial Intelligence”, ”Basic Course on Software Engineering”, but none of them explicitly mention ethics in their learning outcomes. Hence, based on the explicitly stated learning outcomes of the courses, it is not clear if these learning outcomes are covered at sufficient depth in the courses.

For investigation and information retrieval, basic training on how to use library services is provided by the library staff for all starting students as extracurricular support. Many courses and assignments include parts where investigation and information retrieval are a fundamental part of the assignment. Furthermore, the Bachelor´s thesis along with the seminar working around it are closely linked with information retrieval skills.

However, the limited focus on customer-centricity in the curriculum is potentially missing an important perspective of information retrieval: how to identify customer needs. Accreditation team sees that in product and service development market investigation skills are a key opportunity for future development.

For Communication and team-working some courses such as Introduction to Engineering give a proper introduction to an important range of work life skills, e.g., communication and teamwork. Based on a teaching demo session during the site visit, the course also covers some multidisciplinary aspects, e.g., ethical case studies which help train communication soft skills. However, the feedback from students and companies calls for diving even deeper into these aspects, maybe by inclusion to other courses, e.g., by finishing some more course work with a short oral presentation of one’s results.

The curriculum also includes 12 credits of obligatory language and communication studies, which aim to develop the professional language and communication skills and competences needed in the field of ICT. The obligatory language courses cover Swedish and English.

In the self-evaluation report the Bachelor's thesis and seminar is mentioned as an example of such a course, however it seems, based on the interviews with current students and alumni, that due the overload of students per teacher the extent of communication practice is not sufficient. On the basis of excellent feedback regarding courses such as the Capstone project during the Master's programme degree, it could be instructive to implement a similar large-scale team project during the Bachelor's degree programme as well.

Master´s degree programme

The Master`s degree programme structure includes 80 credits of advanced studies in the major subject, including the Master's thesis of 30 credits, a thematic specialization module of 20 credits or minor subject studies (25 credits), and finally other optional studies of 15–20 credits.

The degree programme is divided into study tracks, and the following three tracks are included in the accreditation: (1) Software Engineering (SE), (2) Smart Systems (SS), and (3) Communication and Cyber Security Engineering (CSE).

As explained in the self-evaluation report, the core competence expected from the Bachelor-level covers the previous track-level knowledge in each track's specific competence areas. Knowledge and understanding are extended in the Master-level studies towards current technologies and techniques used in real-life systems. Students expand and apply their skills to a variety of application areas resulting in their own expertise profile. A specialization is gained through minor/thematic study modules and elective studies. Engineering practice in Master-level studies focuses on each track's specific competence areas.

For knowledge and understanding, knowledge of the fundamentals of the ICT field are in general covered well in the course-level learning outcomes. The degree programme does not have any learning outcomes related to, e.g., knowledge of mathematical and physical foundations, as these are expected to be acquired already during Bachelor's studies, and hence there are no compulsory courses on mathematics or physics.

In the *Software Engineering* track, according to the self-assessment report, there are in total 7 compulsory courses that are related to the learning outcomes that fall under the broad theme of knowledge and understanding. Learning outcome 1, "Solid education and expertise in the software engineering field in today's digitalized society", is the broadest, and there are 6 courses that contribute to this learning outcome. All other learning outcomes are covered by at least one course, but there is one notable omission: learning outcome 4, "Practical knowledge of packaging and deploying software systems according to the principles of continuous integration and deployment (CI/CD)", is not covered by any compulsory course.

In the *Smart Systems* track, there are also in total 7 compulsory courses related to the broad theme of knowledge and understanding. For each learning outcome related to knowledge and understanding there are at least 5 compulsory courses that contribute to it.

In the *Communication and Cyber Security Engineering* track, there are also 7 compulsory courses related to knowledge and understanding. All learning outcomes related to knowledge and engineering are covered in at least one compulsory course. One of the broadest learning outcomes here is learning outcome 1 (”Student has a good knowledge of the cyber security of telecommunication systems and their applications”)—there are 5 compulsory courses that contribute to it. Learning outcome 6 (”Students are able to define, design, manage, and analyze network security solutions based on commercial and open source firewall technologies and intrusion detection systems”) is the only learning outcome that is covered by only one compulsory course.

Engineering practice: As mentioned above, the three study tracks of the Master´s degree programme have respectively 10, 8 and 13 learning outcomes.

Besides being different in size, the sets of learning outcomes of these are quite different from each other on the type and coverage of FINEEC reference programme outcomes. For example, while FINEEC Reference Learning Outcomes such as ”ability to conceptualise engineering products, processes and systems”; ”ability to select and practical skills to apply the most appropriate and relevant, established or new and innovative, analytical, computational and experimental methods and computer tools in problem solving”; ”ability to identify, formulate and solve unfamiliar complex engineering problems in new and emerging areas of their specialisation” and ”ability to select and practical skills to apply the most appropriate and relevant design methodologies or to use creativity to develop new and original design methodologies” are covered by the learning outcomes of the SS and CSE degree programme tracks, these are not equally well covered by the learning outcomes of the SE degree programme track. For example, concerning design and practice, the accreditation team considers that compliance with FINEEC Reference Learning ”ability to conceptualise engineering products, processes and systems” is currently questionable and is recommended to be enhanced at the time of the next curriculum update.

For investigation and information retrieval, the Master’s degree programmes include deeper studies in the three tracks, where knowledge is currently developing fast. Therefore, analysis of problems as well as investigation and information retrieval are key skills to manage and complete the courses. In the Master’s degree courses the most complex courses (Capstone and Lean Platform Business Design) require team level collaboration in both analysis and information retrieval. The team level collaboration provides good learning from peers on how the thinking of analysis and information needs can be different regarding the same task depending on the individual.

Furthermore, the Master´s thesis process as whole is closely linked with the investigation and information retrieval skills.

Multidisciplinary competences can be developed either in project work or in selected personal studies. The customer and innovation perspectives are more visible in the Master-level studies than in the Bachelor-level courses.

For Communication and team-working, the Master's degree programme provides students an option to take part in either the Capstone or Lean Platform Business Design courses which combine cooperation of students from different departments and cooperation with companies. Based on their syllabus and feedback these are the backbone of the multidisciplinary approach and provide students with a safe place to train their soft skills. Both of the courses seem to provide enough opportunities to improve communication skills and teamwork mind-set.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 3 conditionally.

Based on the team's assessment, the Master´s degree programme meets Standard 3 conditionally.

Standard 4: The curriculum gives comprehensive information on all the individual courses of the programme, including thesis work and possible practical training, and is accessible to students.

The curricula and the teaching schedules of both degree programmes are published in the study guide that is publicly available on the UTU web site. This also covers the three tracks of the Master´s degree programme, which are included in the accreditation. In general, the study guide provides sufficient information on individual courses and thesis work, including the number of ECTS credits, learning outcomes and the outline of the course content, prerequisites, learning material, teaching language, and the teacher in charge of the course. Curricula are available both in Finnish and English.

For most of the courses, the learning outcomes and the course content is described in sufficient detail. However, the details given in the study guide for the courses "Mathematics for Engineers 1–4" of the Bachelor´s degree programme are somewhat scarce (at the time of the site-visit the development of these courses was currently ongoing and therefore up-to-date information on the detailed content was not available in the study guide—however, this was corrected soon after the site-visit when the updated curriculum was published). While this is not necessarily a major issue for students who follow the typical study path and complete all four courses in linear order, students who follow atypical study paths (e.g., changing universities or changing majors during their studies) would benefit from more details here.

The presentation of the study guide is perhaps geared towards a more expert reader, and it might be beneficial to edit especially the descriptions of the core Bachelor-level courses so that they are accessible also for students who are just planning to start their university studies. For example, an upper secondary school student is not likely to be familiar with the terms ”ER model” and ”OSI model”, and hence it may not be that clear how to interpret the learning outcomes of the first-year courses such as ”Fundamentals of Databases” or ”Computer Network Technologies”. The accreditation team recommends that there could be an informal summary of each course also for non-experts.

As the Bachelor's and Master's theses are a particular area that may need attention (see Section 2.2 below for more discussion), special attention may also be needed in the way the thesis process is described in the study guide (e.g., what are the options available for the student in the choice of topic, what is the process for selecting the topic and finding a supervisor, and what are the steps needed for completing the thesis). Having more information of this type available for students in the publicly available study guide would also help students to plan their thesis work well in advance. In the university intranet there is general university-wide information available on the thesis process, and in the intranet page of the Faculty of Technology there is also faculty-wide information on the thesis process, but especially publicly available information on the programme-specific practices seems to be scarce.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 4 fully.

Based on the team's assessment, the Master´s degree programme meets Standard 4 fully.

Standard 5: The curriculum and the course timetable enable students to graduate in the expected time.

Both degree programmes along with the three tracks of the Master´s degree programme have clearly designed course timetables, which show for each semester the courses included in the degree programmes. Timetables also cover thesis work. Course timetables are available on the university website both in Finnish and English.

Course timetables and teaching schedules of course units and modules are planned for each autumn term and spring term separately. These timetables contain details of the schedules and teaching modes of the courses. The teaching schedule for the autumn term is published by 15 June and the teaching schedule for the spring term is published by 15 November. The teaching schedules are planned in co-operation with the teachers and the department's Education Coordinator. The Education Coordinator makes sure that studies belonging to a certain study year or programme do not overlap.

However, the self-evaluation material shows that the share of students who graduated with a two-level degree with more than 12 months overtime in the last two years was about 55%, which is twice the average/expected amount (the average in UTU is 26%, and average in Finland

22%). It was evident in the interviews that—as is typical in Finland—many students work alongside their studies and actually study part-time, which obviously has an impact on the average study time and progress of the studies. As described in the self-evaluation report, the Academic Engineers and Architects in Finland TEK's annual Graduate Survey shows this evidently: according to a recent survey, 40% of engineering graduates have gained more than 2 years of work experience during their studies, which has often slowed their studies. Furthermore, as there is growing demand for ICT professionals, this poses a challenge for all the ICT degree programmes, not only the ones at the University of Turku. In the self-evaluation report, the degree programmes have identified supporting students in completing their degree studies even if they have been employed during their studies as one of the key areas for development.

Based on student and alumni interviews, there do not seem to be major issues that prevent those students who study full time from completing their degrees within the expected time (3 years for the Bachelor's degree and 2 years for the Master's degree), and generally the course workload is relatively well-calibrated with the number of ECTS credits—teachers respond to feedback on the workload and adjust accordingly.

That said, it seems that there are challenges in completing the Bachelor's thesis in the expected time, which can hold down the whole progress of one's studies. Based on the interviews, this issue appears to be connected—at least partially—to the workload of teachers and high number of supervised students per teacher. Providing procedures that create the prerequisites for starting the dissertation in good time before the end of the nominal study period is also necessary—for example, at the beginning of the penultimate semester of submitting the dissertation project.

Based on the interviews, another challenge that may slow down study times is related to students missing prerequisites for the courses. While students who follow the usual study path through the Bachelor's and Master's degrees will acquire any prerequisites in a natural manner, this may be more challenging for students who have transferred from their previous studies at another institution and do not have personal experience with previous studies at the faculty, e.g., they attend only a Master's degree at UTU. Here, more detailed documentation on the prerequisites (and how to acquire them) may help with students who follow non-traditional study paths.

Yet another issue might be the variety of quality of lectures (see Standard 8 for more discussion). Systematic support and guidelines available for the teachers appear to be helpful. On the other hand, providing students with options of recorded lectures and other online (or other non-stop) available resources for studying seems convenient and significant for a student's progress in both degree programmes. Hybrid teaching materials with a combination of onsite hands-on sessions provide flexibility to adapt learning to personal preferences and needs.

One positive aspect that helps students graduate in time is the reverse learning methodology, which is in use in both degree programmes. Such methodology takes learning beyond learning to reflection and impact making level and improves the learning speed. There are opportunities to use the reverse learning methodology even more and link the class reflection sessions to individual curriculum target follow up: one could include a coaching-like reflection as the core part of the individual student self-assessment and progress monitoring and focus the mind of the student on one's own progress. If the students keep on thinking how each class supports their completion of the curriculum, their minds work to understand their education purpose better.

Another positive aspect is that many courses allow students to get most of the assessment through weekly assignments which could be encouraged even more.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 5 fully.

Based on the team's assessment, the Master´s degree programme meets Standard 5 fully.

Standard 6: The criteria and process for student admission and transfer are clearly specified and published. Students should be informed of the qualifications necessary to enter the programme.

Based on the self-evaluation material as well as information provided in the evidence room and the UTU web site, the admission process to both degree programmes is transparent and well organized. There are rules to guide the whole process and all the necessary information is provided on the UTU web site for the applicants. The options for transferring from other higher education institutions are limited but work according to national regulations and are also published publicly.

The Department of Computing has an assigned Education Coordinator responsible for admission matters as a part of the faculty´s Office for Academic and Student Affairs, who coordinates student admissions and organizes the practical arrangements of the admissions, prepares the quota and admission requirements in collaboration with the faculty's administration and department's staff, cooperates with other universities in admission matters, and offers guidance for applicants.

Applicants are provided adequate information on the entry-level qualifications, number of students admitted per year as well as on the full curricula, Master´s degree programme´s track options and courses available. In addition, the focus areas of the Department of Computing are presented both for education and research as well as key partnership institutions. Career opportunities are reflected both for the industry and the research for each Master´s degree programme´s track. Information aimed for the applicants also includes a description of the role of the Master´s thesis and examples of the topics of recent theses completed within the tracks.

However, the accreditation team recommends that it might be useful to identify, illustrate and communicate a few unusual but potential paths to becoming a degree programme student other than as fresh upper secondary school graduates. If the university aims to increase the number of students, the potential may come from paths that are not traditional: how to enter from certain universities of applied sciences, how to attract people from businesses, etc.

All Finnish universities have a yearly joint application period and system for all degree programmes taught in Finnish. In order to be eligible to apply, the applicants must fulfil the formal eligibility requirements for admission to Bachelor' s studies as defined in the Finnish university legislation (Universities Act 558/2009, §37). The admission requirements are published yearly in late October. The joint application period takes place in late March and lasts for two weeks. During the application period, one can apply for both Bachelor-level and Master-level studies (if admitted, the study right includes both the Bachelor's and Master's degree in the same field) and Master's level studies only (for the applicants that have already completed their Bachelor's in another university or university of applied sciences in Finland). All admission results will be published by a national deadline in early July.

The Finnish universities offering degree programmes in technology and in architecture have a joint DIA admission process. In the DIA joint application, the coordinating university (Aalto University) is responsible for marketing, planning of student admissions, processing of applications for matriculation examination -based admission, and coordination of entrance examinations. The coordinator is also responsible for joint scoring models and evaluation of the entrance examinations made by a group of academic staff members from each attending university and finally publication of results once admission decisions have been made in each university. In the DIA there are 51 degree programmes using the same admission criteria, i.e. the same scoring of the matriculation examination results and the same entrance examination. The admission requirements are published at dia.fi and separately for each program at studyinfo.fi. 80% of the admission quota is filled based on the matriculation examination (incl. EB, IB, RP/DIA) grades. 70 % of the study places are assigned to first-time applicants. To be eligible to apply in this quota the applicant must have the minimum grade of cum laude approbatur (C) in mathematics (advanced syllabus) in the matriculation examination certificate. 20% of the quota is filled based on entrance examination success. 70 % of these study places are assigned to first-time applicants. The entrance examination is held at the same time (once a year) in all DIA universities. The examination is composed of two parts: an obligatory mathematics part and an alternative part with chemistry, physics, and problem-solving questions.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 6 fully.

Based on the team's assessment, the Master´s degree programme meets Standard 6 fully.

Standard 7: Students are informed of regulations and guidelines that concern recognition of prior learning, progress of studies and graduation.

Based on the self-evaluation material as well as information provided on the UTU web site, the university and the degree programmes have relevant regulations and processes in place for the recognition of prior learning.

Detailed information on the process of recognition is provided for the students in the UTU intranet. Students can apply for the recognition of studies completed in other Finnish or foreign higher education institutions or other institutions in their degree, provided that the learning outcomes for the degree and its parts defined in the curriculum are met. Credits from studies completed elsewhere can be transferred to the degree as such or studies may be used to compensate for studies (course units or modules) in the degree. A student may also have competence acquired in some other way than formal learning recognised and included in the degree or use it to compensate for studies in the degree. According to the self-evaluation report, studies included in another academic degree of the corresponding or higher level can be recognised in a Bachelor's degree for a maximum of 45 credits and in a Master's degree for a maximum of 30 credits. Students apply for recognition of prior learning using an electronic form. The decision on the credit transfer is made by the Education Coordinator. A statement from the department is required in the substitution of specific courses, transferable studies and transfer of credits based on competence attested in some other way than formal education. The Centre for Language and Communication Studies decides on the recognition of language studies included in the degree programmes.

However, the process of recognition could be more clearly described for the students and other interested parties on the UTU web site. Exact information about the number of recognised credits etc. are missing, which is probably caused by mainly focusing on onboarding fresh upper secondary school graduates.

In case of the admissions directly to the Master´s degree programme tracks, the relevant entry qualifications are described on the UTU web site. In addition to applicants from other universities, this also covers applicants having a Bachelor´s degree in engineering from universities of applied sciences. Once the students have been admitted, they may be required to do complementary studies if the content of their previous degree does not provide enough entry-level competences to all the Master´s degree courses. Complementary studies are defined in the personal study plan (HOPS in Finnish) separately for each student.

The target times of the studies as well as allowed maximum times of the studies follow the national regulations. A student admitted to study for both a Bachelor's and Master's degree must complete the degrees in seven years and a student admitted to study only for a Master's degree has the right to complete the degree in four years. If a student does not graduate within the maximum time, (s)he needs to apply for additional time to complete the studies.

The progress of studies is also followed on the course-level in a manner which also informs students on their progress and provides possibilities to discuss possible challenges. For example, especially on Master´s level courses there are usually some mid-deadlines to facilitate students' progress during the courses. In addition, if students are missing an obligatory part of the course, the submission of an extra assignment is usually required.

Detailed information on the graduation procedure is provided for the students in the UTU intranet. At the time of graduation, a student fills in the electronic degree application form once all the courses and modules of a degree are completed and registered. Graduation is possible throughout the year. The Education Coordinator makes sure that all the required studies are completed. The head of academic and student affairs and the vice dean of the faculty sign the certificate. The certificate includes a transcript of the degree and a Diploma Supplement. A Diploma Supplement in English is issued for all students who complete a degree at the Faculty of Technology.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 7 fully.

Based on the team's assessment, the Master´s degree programme meets Standard 7 fully.

Strengths, good practice and areas for further development regarding section 2.1: planning of the programme.

The team notes the following strengths and good practice in this section:

1. The degree programmes have a clear engineering profile, with an emphasis on problem-solving and product-development skills.
2. The degree programme aims are well-aligned with the mission and strategy of the multidisciplinary university.
3. There are several stakeholder groups whose needs have been extensively analysed when developing the degree programmes.

The team sees the following as areas for further development in this section:

4. Clarifying the independent role of the Bachelor's programme as a programme that produces engineers, and not just prepares students for further studies in the Master's degree programme.
5. Covering also non-technical multidisciplinary competences (e.g., environment and health) sufficiently in both programme-level and course-level learning outcomes.
6. Unifying the way in which the learning outcomes of the three tracks of the Master's degree programme are described and presented.

2.2 Implementation of teaching and learning

Standard 8: The teaching and learning process, including the assessment of students, enables students to demonstrate that they have achieved the intended course and programme level learning outcomes. Students have an active role in co-creating the learning process and the assessment of students reflects this approach.

Based on the alumni and stakeholder interviews, the two degree programmes under review together manage well to achieve their main goal: the graduates are *engineers*, with the right problem-solving mind set, with strong programming skills, and who are eager to learn more. In the self-evaluation report, the degree programmes under review have identified the rapid and constant development of the ICT field being one of the main challenges to be taken into account in the development of education, as well as a need to balance between a strong technical foundation and skills needed in working life. The accreditation team agrees with the degree programmes on these views.

However, there are two main areas of development where students do not seem to sufficiently achieve the learning outcomes that are relevant for stakeholders or part of the FINEEC reference programme outcomes:

Work-life skills. In the interviews, the external stakeholders expressed the concern that graduates are lacking in their abilities of handling uncertainty, ambiguity, and non-linearity, and other similar challenges encountered in real-world problems. They were also concerned that not all the graduates are familiar with the usual norms and conventions of the workplace, e.g., understanding nine-to-five presence and the importance of meeting deadlines and following a plan. While the degree programmes are developed in collaboration with the stakeholders, these needs of the employers seem to be partially overlooked in the implementation.

Non-technical multidisciplinary competences. The programme aims highlight the solid scientific foundation acquired in the multidisciplinary university, and non-technical multidisciplinary competences such as the understanding of societal, health and safety, environmental issues is also part of the FINEEC reference programme learning outcomes. However, students seem to encounter such issues in only a sporadic manner; systematic exposure to such questions seems to be lacking. In the self-evaluation report, the degree programmes have defined embedding aspects of sustainable development better in the curricula and courses as being one of the key areas in need of development. Furthermore, according to the self-evaluation report, multidisciplinary skills can be acquired through minor studies and by completing compulsory studies in business. However, as minors chosen by students vary, they do not fully ensure coverage of non-technical multidisciplinary competences. This will be discussed in more detail under ”Multidisciplinary competences” below.

In the two degree programmes under review, the teaching methods largely follow the usual practices of the field: especially in the first Bachelor-level courses, group sizes are larger, more traditional lecture-based teaching is favoured, and courses are often based on standard textbooks, while in more advanced Master-level courses, group sizes are smaller, teaching methods are more versatile, and students get to work on project that are close to the state-of-the-art research conducted in the institute.

Distance learning and flipped classroom teaching are supported by the Echo360 video platform, the Moodle virtual learning platform and the Ville learning platform. An increasing part of the teaching materials is provided in electronic form. Interviews confirmed that providing hybrid resources such as videos and books in digital format is appreciated by students and allows them to personalize their study style through flexibility.

It is common that advanced Master-level students participate in research projects at the Department of Computing. Thesis work topics are typically connected to the department's research projects or the needs of external stakeholders.

It is evident that in both degree programmes that there are many enthusiastic and talented teachers and based on the site visit as well as the evidence room materials they are able to apply modern, more innovative and interactive teaching methods also in the context of large Bachelor-level courses. Also in the self-evaluation report it is seen as one the degree programmes' key strengths that the teaching staff has good pedagogical capacity and knowledge in engineering pedagogy. However, based on student interviews there also seems to be a lot of variance in the quality of the course implementation, depending on who teaches it. The challenges mentioned especially by the Bachelor-level students included outdated slides and textbooks that do not reflecting the latest technology, and students had the impression that not all teachers are putting enough effort in preparing high-quality study material.

Especially in the Master's degree programme, the accreditation team was happy to see impressive courses with highly relevant up-to-date content, and exciting hands-on elements that are likely to greatly facilitate learning. A particular highlight is the Capstone course, which was often mentioned as a positive example in the student interviews. The teaching demo sessions included in the site visit confirmed these findings.

Both degree programmes have personal study plans ("HOPS" in Finnish) in use. Personal study plans are drafted jointly by students and their designated guiding teachers (MyTeacher system; discussed in more detail in Section 2.3). Even though the student population is rapidly growing, students are nevertheless seen as individuals from the perspective of the management of the degree programmes. Already in the Bachelor's program there is flexibility and freedom that students appreciate. However, the number of students per teacher is quite high, and this is also visible in the amount of attention individual students can get; resource issues are discussed in more detail in Section 2.3.

There seems to be one part in both degrees where the teaching and learning process could be improved: the Bachelor's thesis and the Master's thesis. The number of students completing the Bachelor's thesis within the expected time frame is low, based on the interviews in the ballpark of only 50%. The alumni also reported challenges and delays related to the Master's thesis phase in the interviews. This is one concrete area of improvement: developing processes that ensure that the theses get started without unnecessary delay, there is sufficient monitoring of the students' progress, and students get sufficient support that enables them to successfully complete their thesis in time. Difficulties in completing the thesis in time may also indicate that the other courses in the degree programme have not prepared students sufficiently for the thesis work, and hence the students cannot focus primarily on the content of the thesis.

Now that we are moving towards the post-COVID-19 world, both degree programmes may need to boldly re-think their teaching after the pandemic: Which courses are web-based basic courses with assisting personnel? Which courses use reverse teaching methods and which courses use social approaches? In which courses can peer review be a good approach, in which courses professional feedback is useful, and in which courses business life has its role? Where to use the web-lectures from the best universities and complement them with support from the local teaching staff?

Bachelor's degree programme

Knowledge and understanding

- knowledge and understanding of mathematics, computing and other basic sciences underlying their engineering specialisation, at a level necessary to achieve the other programme learning outcomes;
- knowledge and understanding of engineering fundamentals underlying their specialisation, at a level necessary to achieve the other programme learning outcomes, including some awareness at the forefront;
- knowledge and understanding of applicable materials, equipment and tools, engineering technologies and processes, and of their limitations, in their specialisation
- knowledge and understanding of applicable techniques and methods of analysis, design and investigation, and of their limitations, in their specialisation;

The Bachelor's degree programme has got a good selection of computer science topics that build a solid foundation for the degree. A particular highlight of the degree programme is the way in which it builds a foundation for understanding the principles of computing by discussing not only the software stack but by going all the way to the low-level details of computing hardware and electronics.

The coverage of mathematics is typical, both in volume (19 ECTS) and in the choice of topics (e.g., basic algebraic structures, discrete mathematics, linear algebra, complex numbers, differential and integral calculus, probabilities and statistics, and Fourier analysis).

In terms of building foundations, one of the strengths of the degree programme is the amount of physics in the programme (4 courses, 16 ECTS credits in total)—this is more than what one would expect from a graduate in ICT, and this could be a competitive advantage also in the job market. Indeed, one of the foundational questions of the field is understanding the limits of efficient computation in the physical world in which we live, and this will require plenty of understanding of the laws of physics. However, this also seems to be a somewhat underused opportunity: there seem to be few ICT courses in the programme that have any prerequisites related to physics—the ”Fundamentals of Electronics” course has got ”Basics in Physics 2” as a prerequisite, but there do not appear to be any courses that would directly build on the 3rd and 4th physics course. If a significant fraction of the degree is devoted to physics, it would be important to also make sure that students could directly benefit from it also in their major studies.

Teaching methods in the courses related to knowledge and understanding make use of not only traditional lectures, demonstrations, and exercise sessions, but also more modern online tools such as video lectures, online learning platforms with automatically assessed exercises, and discussion forums that provide peer support. Some but not all courses have an exam that may contribute, e.g., 50% of points for grading; the rest of the grade comes from various exercises and projects. Especially in many courses related to ICT topics, practical hands-on exercises and projects play a key role in both teaching and assessment—students not only learn the theoretical principles of computer programming, computing systems, and hardware, but they put this knowledge in practical use already during the same course.

Engineering practice: analysis, problem-solving, design, practice

The courses in the Bachelor’s degree programme cover basic skills related to engineering in general, as well as skills related to the ICT field more specifically. The self-evaluation report lists ”Basic Course on Software Engineering”, ”Programming Lab Course”, ”Web and Mobile Programming”, and ”Skills for Study and Work: Tools for Programming” as key courses related to engineering practice. Teaching methods in these courses include, e.g., online lectures, question-and-answer sessions, individual exercises, group exercises, and essays. The courses put heavy emphasis on hands-on exercises: students are assessed primarily based on various practical exercises, laboratory work, and projects—based on the self-evaluation report and its appendices, e.g., theory-heavy final exams are not so common in these courses. In general, the teaching and assessment methods seem to be well-aligned with the goal of educating engineers with practical engineering skills.

Analysis

- ability to analyse complex engineering products, processes and systems, and to correctly interpret the outcomes of such analyses, by being able to select and having the practical skills to apply relevant established analytical, computational and experimental techniques and methods

Some of the Bachelor-level courses (e.g., ”Basic Course on Software Engineering”) take an approach in which the entire life cycle of an engineering project is covered, and analysis skills and techniques are covered as an integral part of the project. The ”Introduction to Engineering” course takes a more generic or meta-level view to analysis in the engineering profession.

Problem-solving

- ability to identify, formulate and solve complex engineering problems, by being able to select and having the practical skills to apply relevant established analytical, computational and experimental techniques and methods

Many of the courses in the Bachelor's degree programme include assignments and projects that ask students to solve an engineering problem, and hence students will get practice in problem-solving skills. However, it seems that the problems that the students encounter in the course work are typically clear and well-defined. Clarity in assignments is of course often desirable, especially in the first Bachelor-level courses. However, such problems are perhaps not that representative of the problems one encounters in the real world—in the interviews the external stakeholders expressed the concern that graduates are lacking in their abilities of solving problems that involve uncertainty and ambiguity.

Design

- ability to develop and design complex products (devices, artefacts, etc.), processes and systems to meet established requirements that can include societal, health and safety, environmental, economic and industrial constraints, by being able to select and having the practical skills to apply relevant design methodologies
- practical skills for realising complex engineering designs
- ability to use the awareness of the forefront of their engineering specialisation in design and development

For design skills, a set of courses of traditional type is offered. To facilitate learning, students get some design tasks in some courses (Programming Lab Course, Advanced Course in Object Oriented Programming, System Engineering Labs, Embedded Microprocessor Systems, Basic Course on Software Engineering, Distributed Software Systems and Cloud Services, User Interfaces, Digital Signal Processing, Web and Mobile Programming, Digital Communication Systems). However, these are relatively specific and focus on the development of a concrete item. The Programming Lab Course is, in fact, the only course in which students complete a large-scale project-type assignment to solve a practical computing problem. On the other hand, this practical problem may include some societal, environmental, economic, etc. aspects. It should be mentioned that Programming Lab course is part of the Software module, so it may not be taken by all students in the curriculum. Especially in the Software module, it would be important to ensure that each student experiences the complete software development cycle, using methods and environments similar to what one encounters in the industry.

As an area for improvement, the Systems Design module could also contain a project-type course in which students design and develop a practical solution (another option would be to revise the content of the ”System Engineering Labs” course by replacing a set of project-oriented exercises with one more complex task).

Another aspect that could be considered is the horizontal sharing of experiences between students. For example, the ”Programming Lab Course” course could end with a conference to introduce and discuss the progress of the projects and the results obtained.

Practice

- ability to apply norms of engineering practice in their engineering specialisation;
- ability to consult and apply codes of practice and safety regulations in their engineering specialisation

As discussed in Section 2.1, many of the students work during their studies, and hence many students will also acquire important skills related to the practice of being an engineer in the ICT field, as well as learn to understand the norms and conventions of the workplace.

However, as the degree programme does not contain, e.g., an obligatory internship, there is potential for a lot of variance in the practical engineering skills that the graduates acquire. Although the university has competent staff to provide a high level of practical engineering training, some important aspects may not be sufficiently taken into account. For example, one challenge that was discussed in the interviews with external stakeholders was the ability to resolve problems when the source data is incomplete, the goal is not well defined, or there are other interfering factors that affect the resolution of the problem. Solving these kinds of problems in practical professional activities requires the ability to set clear criteria and consider between different options. Uncertainty and a plethora of choices are particularly prevalent in complex problems. Therefore, more involvement of top industry professionals in university studies and the introduction of compulsory industry placements could be considered.

Another factor that may hinder the acquisition of modern practical skills is the design of the IT classrooms: the layout of the classrooms is primarily designed for traditional individual work, with each student working on their own project on their own computer, and hence it does not support that well the use of modern team-based agile development methodologies. Thus, the working methods and skills acquired during studies at the university may somewhat differ from those applied in companies.

Investigations and information retrieval

- ability to conduct searches of literature, to consult and to critically use scientific databases and other appropriate sources of information, and to carry out simulation and analysis, in order to pursue detailed investigations and research of technical issues
- ability and practical skills to design and conduct experimental investigations, interpret data and draw conclusions
- ability to work in a laboratory/workshop setting

The Bachelor's degree programme includes courses in which students have to look for material outside lecture materials and figure out how to make the content suitable for a specific use: seminars on contemporary topics (Seminar on Computer Science), courses of communications (Academic writing skills), project work (Applied Project). Many courses also include visiting lectures that provide new ideas for innovative thinking.

The Bachelor's thesis and seminar course provide lectures on sources and database use and scientific writing in groups and where fellow students provide peer support in learning. The library services provide also additional support and teaching for reference management. Students are expected to be active participants and the courses encourage students to take opponent roles in the seminars.

Especially in the System track there are courses (e.g., "Embedded Microprocessor Systems") with hands-on assignments and projects in which students learn to work in a laboratory setting. In the Software track students learn to run experiments in, e.g., virtual machine and cloud computing environments.

Multidisciplinary competences

- awareness of the wider multidisciplinary context of engineering
- awareness of societal, health and safety, environmental, economic and industrial implications of engineering practice and recognition of the constraints that they pose
- awareness of economic, organisational and managerial issues (such as project management, risk and change management) in the industrial and business context
- ability to gather and interpret relevant data and handle complexity to inform judgements that include reflection on relevant social and ethical issues;
- ability to manage complex technical or professional activities or projects, taking responsibility for decision making
- ability to recognise the need for and to engage in independent life-long learning
- ability to follow developments in science and technology

Multidisciplinary competences in the Bachelor's programme are acquired through courses such as ”Embedded Microprocessor Systems”, ”Mathematics for Engineers 1”, ”Basics in Physics 1”, and ”Finnish Written Communication, Engineering Sciences”. The teaching methods vary between the courses, but, e.g., the ”Embedded Microprocessor Systems” course makes use of online and live lectures, self-study material, weekly exercises, weekly workshops, automatically graded quizzes, and a final exam, and there is also online assistance available to students both in Teams and by email. In general, in the courses that provide multidisciplinary competences, specific competences are assessed with exercises and written exams, while there are broader assignments and projects in which students need to apply knowledge from different fields.

As discussed earlier, students of the Bachelor's degree programme obtain a broad understanding of the *technical* context surrounding their own area of specialization. For example, students are exposed to, e.g., questions related to electrical engineering, embedded systems, and hardware, and more generally to the practice of engineering.

However, there seems to be limited exposure to *non-technical* issues, such as society, health, safety, and the environment. There are some courses that discuss ethical issues, especially in the context of cybersecurity (even though ethics is not listed in the learning outcomes of the courses). However, other non-technical challenges seem to be largely lacking from the curriculum and from the learning outcomes of the courses of the Bachelor's degree programme.” In the interviews, Bachelor-level students were able to give only a few examples of them encountering such issues in their courses—there were some isolated examples in elective studies, minors, and Master-level courses, but a systematic exposure to such questions seems to be lacking in the mandatory parts of the degree programme.

The University of Turku is a multidisciplinary university, with many departments and degree programmes where, e.g., societal and environmental issues are at the very core of their disciplines. This could be a great opportunity for the ICT degree programmes to make better use of the other departments in exposing ICT students to such non-technical challenges, either by directly incorporating other disciplines in the existing ICT courses, or by including courses from other disciplines in the ICT degree programmes.

Communication and team-working

- ability to communicate effectively information, ideas, problems and solutions with the engineering community
- ability to communicate effectively information, ideas, problems and solutions with the society at large;
- ability to function effectively in a national and an international context;
- ability to function effectively as an individual and as a member of a team;
- ability to cooperate effectively with engineers and non-engineers.

Examples of courses related to communication and teamworking skills include ”Basics of Programming – Exercise”, ”Bachelor’s thesis and seminar”, and ”Programming Lab Course”. The courses make use of projects and reports that are done as group work, written reports, and oral presentations to practice and assess these skills.

The Bachelor’s thesis plays a major role in learning written communication skills, while various course projects provide opportunities for learning to work in a team. However, it seems that in the Bachelor’s programme the projects solved as teams are relatively small, the teams are small, and there is little need to, e.g., communicate with non-engineers. For example, the self-evaluation material mentions the course ”Basics of Programming – Exercise” that aims to teach how to implement a small project in a small group, but the volume of the course is only 2 credits and it is possible to solve the project as a team with only one student. This can be compared with the Master’s degree programme, where there is a major ”Capstone” course or the ”Lean Platform Business Design” course that is worth 10 credits, and typically involves teams with 5–8 students. Furthermore, the projects in the Master’s degree programme often involve external stakeholders and multidisciplinary aspects, while it seems that the teamwork in Bachelor-level courses is mostly done in more homogeneous teams that consist of engineering students. From the perspective of acquiring sufficient skills related to working effectively in large multidisciplinary teams and communicating with non-engineers, it may be beneficial to consider introducing a large capstone-style final project also in the Bachelor’s degree programme.

Knowledge and understanding

- in-depth knowledge and understanding of mathematics, computing and sciences underlying their engineering specialisation, at a level necessary to achieve the other programme learning outcomes
- in-depth knowledge and understanding of engineering disciplines underlying their specialisation, at a level necessary to achieve the other programme learning outcomes;
- critical awareness of the forefront of their specialisation
- comprehensive knowledge and understanding of applicable materials, equipment and tools, engineering technologies and processes, and of their limitations;
- comprehensive knowledge and understanding of applicable techniques and methods of analysis, design and investigation and of their limitations;

In the Master's degree programme, there are courses with deep, relevant technical content that enable students to become experts in their area of specialization. The understanding of ICT that the students acquire in the programme goes way beyond the higher levels of the software stack, all the way to hardware.

Examples of courses that contribute to in-depth knowledge and understanding in the Master's degree programme include ”Network Infrastructure technologies and Security” and ”System and Application Security” (in the Communication and Cyber Security Engineering track), ”Autonomous Systems Architectures” (in the Smart Systems track), and ”Programming Paradigms in Practice” (in the Software Engineering track). The teaching methods employed in these courses include traditional lectures, video lectures, presentations given by students, guest lectures from industry, and assignments that are solved individually and in groups. The assessment methods in the courses related to these topics include weekly written reports, learning diaries, and final exams.

As is usual in the ICT field, sufficient mathematical foundations, as well as basic understanding of physics, are already acquired during Bachelor's studies; the Master's degree programme focuses on bringing students to the forefront in their own area of specialization.

Engineering practice: analysis, problem-solving, design, practice

All three tracks of the Master's degree programme contain a number of courses with hands-on exercises and projects that enable students to acquire practical engineering skills. Examples of such courses include ”Firewall and IPS Technology” and ”Communications

Technologies and Security in IoT" (in the Communication and Cyber Security Engineering track), "System Modelling and Synthesis with HDL", "Hardware Accelerators for Robotics and AI", "Perception and Navigation in Robotics", and "Robotics and Autonomous Systems" (in the Smart Systems track), and "Usability, User Experience and Analytics", "Software Design and Architecture", "Advanced Course on Software Engineering", "Software Testing and Quality Assurance", and "Privacy and Security for Software Systems" (in the Software Engineering track).

The teaching methods of these courses make use of practical laboratory exercises and projects that are solved individually and in small teams. Students get to use the same software suites that are also used in the industry. Some of the courses also involve other elements such as learning journals, presentations, workshops, and final exams. Assessment in courses related to these topics put emphasis on practical exercises, projects, reports, and presentations.

Analysis

- ability to analyse new and complex engineering products, processes and systems within broader or multidisciplinary contexts, and to critically interpret the outcomes of such analyses, by being able to select and apply the most appropriate and relevant, established or new and innovative, analytical, computational and experimental methods and tools,

Based on the alumni and stakeholder interviews, it is evident that students acquire strong practical programming skills, and a key part of programming skills is the ability to analyse the problem at hand. In the "Capstone" and "Lean Business Platform Design" courses students are put before a challenging and complex task that requires collaboration of diverse skills from different programmes. The reverse teaching method requires from the students the capability to reflect on the course content. As an end result students become engineers with the right "engineering mindset".

Problem-solving

- ability to identify, formulate and solve unfamiliar complex engineering problems in new and emerging areas of their specialisation. The problems can be incompletely defined, have competing specifications and may involve considerations from outside their field of study and have non-technical – societal, health and safety, environmental, economic and industrial – constraints.

A key part of the engineering mindset is being able to solve problems, and based on, e.g., alumni interviews, the graduates indeed seem to perceive themselves as problem-solvers. Problem-solving skills are practiced in a number of project-based courses throughout the

Master’s studies, and especially the big final-year projects provide students with opportunities to learn how to solve complex engineering problems, and many of the projects also have non-technical elements.

However, in the stakeholder interviews it was noted that the graduates are lacking in their ability to deal with problems that involve uncertainty, ambiguity, and non-linearity. It seems that perhaps the course projects are a bit too streamlined and polished, and do not prepare students sufficiently for the problems that they encounter in the real world.

Design

- ability to conceptualise engineering products, processes and systems;
- ability to design and develop new and complex products (devices, artefacts, etc.), processes and systems, with incompletely defined and/or competing specifications that require integration of knowledge from different fields and non-technical – societal, health and safety, environmental, economic and industrial commercial – constraints;
- ability to design using knowledge and understanding at the forefront of their engineering specialisation.

Design tasks and assignments are included in the content of several courses. Some courses have design tasks or projects in the assessment criteria. The project-based courses ”Capstone” and ”Lean Platform Business Design” play a special role in the development of design competencies. These courses were positively described by both the teaching staff and students in the interviews. On the other hand, each project focuses typically on some specific aspect of society, health, the environment etc., but broad, systematic exposure to these issues is lacking. One possible way to alleviate this issue is to make more extensive use of horizontal sharing of experiences between students, for example, at the end of each course with project-type assignments.

Another possibility to strengthen the ability of students to conceptualise engineering products, processes and systems is to include this aspect also in the description of the content of the Master’s Thesis in Technology.

Practice

- ability to select and practical skills to apply the most appropriate and relevant, established or new and innovative, analytical, computational and experimental methods and computer tools in problem solving.
- ability to select and practical skills to apply the most appropriate and relevant design methodologies or to use creativity to develop new and original design methodologies.
- practical skills, including the use of computer tools, to realise complex engineering designs

Many Master-level courses contain elements that provide students with practical experience of the same tools and methods that are used in industry. For example, in the Smart Systems track, students use industrial-level software suites for hardware verification, synthesis, and prototyping.

Many students also do internships in industry during their studies (see Section 2.1). However, in spite of the large number of students doing internships during their studies, in the stakeholder interviews the companies noted that the graduates nevertheless do not always seem to understand the norms and conventions of the workplace, and as noted above, the students are also lacking with the ability to deal with, e.g., incomplete data, ill-defined goals, and other interfering factors.

Part of the explanation may be that similar to the Bachelor's degree programme, the Master's degree programme does not contain obligatory internship, and hence the programme does not ensure that all students get a certain minimum amount of experience of working in the industry. The accreditation team recommends that the role of the industrial internships is strengthened also in the Master's degree programme.

Investigations and information retrieval

- ability to identify, locate and obtain required data;
- ability to conduct searches of literature, to consult and critically use databases and other sources of information, to carry out simulation in order to pursue detailed investigations and research of complex technical issues;
- practical skills, including the use of computer tools, for designing and conducting complex investigations;
- advanced laboratory/workshop skills and ability to design and conduct experimental investigations, critically evaluate data and draw conclusions;
- ability to investigate in a creative way the application of new and emerging technologies at the forefront of their engineering specialisation

In the Master's degree programme, students acquire investigation and information retrieval skills especially when writing their Master's thesis, but also in large project courses such as the Capstone course. Teaching and assessment is typically based on reports, essays, and presentations.

From the perspective of teaching methods, an interesting case is the "Network Infrastructure technologies and Security" course (in the Communication and Cyber Security Engineering track). Here the first half of the course is based on lectures that cover the basics, but in the second half of the course the students need to do their own research on more advanced topics and present their findings.

Overall, the teaching methods seem to be very effective in these areas. The investigation and information retrieval perspective got a lot of positive mentions in the stakeholder interviews: ”Students have a good ability to find information, ask questions, hungry to learn”. One of the stakeholders perceived Master-level students to be exceptionally talented in information retrieval from external sources. Also, the alumni mentioned in the interview information retrieval skills as one of the key outcomes of the degree programme. In summary, the degree programme has been able to create a strong culture for information retrieval practices.

During the facilities tour, the accreditation team was able to visit a number of different laboratory and workshop spaces, and it is evident that these spaces are also actively used for teaching. Many Master-level courses have advanced projects in which students acquire the skills of working in a laboratory environment, conducting experiments, and analysing the findings.

Multidisciplinary competences

- critical awareness of the wider multidisciplinary context of engineering and of knowledge issues at the interface between different fields.
- knowledge and understanding of the non-technical – societal, health and safety, environmental, economic and industrial – implications of engineering practice;
- critical awareness of economic, organisational and managerial issues (such as project management, risk and change management)
- ability to apply norms of engineering practice
- ability to consult and apply codes of practice and safety regulations;
- ability to integrate knowledge and handle complexity, to formulate judgements with incomplete or limited information, that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgement to deliver sustainable solutions for society, the economy and environment;
- ability to manage complex technical or professional activities or projects that can require new strategic approaches, taking responsibility for decision making.
- ability to engage in independent life-long learning;
- ability to undertake further study autonomously.

In the Master’s degree programme, multidisciplinary competences are acquired primarily through collaboration in groups with members from different disciplines. Here the Master’s degree programme has got similar strengths and weaknesses as the Bachelor’s degree programme (see above): on the one hand, students are exposed to *technical* issues more broadly beyond their own area of specialization, but there is only limited and somewhat sporadic exposure to *non-technical* issues.

Depending on the specialization, many students get to deal not only with the software side of ICT but also the hardware side of ICT. Especially in the Smart Systems track, students deal with, e.g. electronics, wireless communication, and even mechanical engineering. In Communication and Cyber Security track students also encounter non-technical questions related to ethics.

However, systematic exposure to societal and environmental issues seems to be lacking. In the ”Capstone” course and in the ”Lean Platform Business Design” course many students have projects that pertain to some *specific* challenge related to, e.g., health or the environment. There also seems to be lot of variance—in the interviews one of the Master’s degree students admitted that they had not encountered any questions that they would classify as being related to society and the environment in their studies.

Even if all students had sporadic encounters of non-technical issues, this does not yet enable them to understand, e.g., the broader context and foundational ideas related to such challenges. It would be helpful for engineers to understand the philosophy and the mindset of other disciplines (and vice versa), in order for them to be able to work together in multidisciplinary contexts.

The accreditation ream repeats here the recommendation which was made in the context of the Bachelor’s degree programme: as the institute is a multidisciplinary university, there would be great opportunities for integrating, e.g., core courses from the other disciplines systematically in the ICT programmes. While it would be good to enable and encourage students to take free elective courses and minors that help to develop their understanding of non-technical issues, the degree programme should ensure that all students, regardless of the choices they make during their studies, get a solid understanding of the broader multidisciplinary context of engineering.

The accreditation team also encourages the degree programme to try to identify small changes that would enable students, e.g., in the Capstone and Lean Platform Business Design courses to get a maximal benefit from the non-technical issues that *other* groups of students have encountered in their projects.

One area where the degree programme seems to be strong is preparing the graduates with the ability to engage in life-long learning and to undertake further study autonomously. Indeed, as was observed both in the stakeholder interviews and alumni interviews, the students are eager to learn more, and able to find information (see above).

Communication and team-working

- ability to use diverse methods to communicate clearly and unambiguously their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences in national and international contexts;
- ability to function effectively in national and international contexts, as a member or leader of a team, that may be composed of different disciplines and levels, and that may use virtual communication tools.

As is common in Finland, basic studies in languages and communication are included in the Bachelor-level studies and students are supposed to have skills and competences concerning them when entering the Master´s degree programme. Therefore, there are no separate courses for these topics in the Master´s degree programme; and the advanced skills and competences in this field are gained as a part of the substance courses. As the number of courses conducted online or as a hybrid solution is growing, there are good conditions for learning to use virtual communication tools, too.

The degree programme has practices which support acquiring the skills needed for working as a professional in the international context. The degree programme offers students possibilities for exchange periods outside of Finland as a part of the degree studies. According to the statistics in 2018–2020, the Department of Computing has received approximately 10 exchange students annually. The number of out-going students has been approximately the same. As noted by the degree programmes in the self-evaluation report, the numbers of international mobility in exchange are not very high, but the Department of Computing's Master's degree programmes host a high number of international students. Furthermore, it is explained in the self-evaluation report, that the aim is to strongly embed internationalization at home in the teaching of the degree programmes, along with the curriculum. As the Master-level courses are primarily taught in English, they are therefore strongly integrated with international Master's degree education, hence allowing students from different degree programmes to interact.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 8 conditionally.

Based on the team's assessment, the Master´s degree programme meets Standard 8 conditionally.

Strengths, good practice and areas for further development regarding section 2.2: implementation of teaching and learning

The team notes the following strengths and good practice in this section:

7. The degree programmes manage to achieve their main goals well: they produce engineers, with the right problem-solving mind set, with strong programming skills, and who are eager to learn more.
8. The degree programmes build a solid foundation for understanding the principles of computing by going all the way to the low-level details of computing hardware and electronics.
9. There are several high-quality Master-level courses with advanced content, and in particular the ”Capstone” course is often mentioned as a highlight of the degree programme.
10. The degree programmes make effective use of a wide variety of teaching and assessment methods, both on campus and online.

The team sees the following as areas for further development in this section:

11. Ensuring that students acquire sufficient work-life skills, e.g., by integrating internships more tightly into both degree programmes.
12. Ensuring that students acquire sufficient non-technical multidisciplinary competences, e.g., by making better use of the opportunities provided by the multidisciplinary university.
13. Providing more opportunities in the Bachelor's degree programme for project-type assignments in which students solve practical computing problems.
14. Implementing more extensive horizontal sharing of experiences between students, e.g., at the end of each course with project-type assignments, especially for Master's degree students.
15. Making better use of the large amount of physics studied in the Bachelor's degree programme, by connecting the ICT courses more explicitly with the concepts covered in the physics courses.
16. Reducing variance in the quality of implementation between different courses.

2.3 Resources

Standard 9: The academic staff are sufficient in number and qualification to enable students to achieve the programme learning outcomes. There are arrangements in place to keep the pedagogical and professional competence of the academic staff up to date.

The teaching staff is appointed according to pre-defined recruitment criteria. The recruitment policy of academic staff is described in the OTM-R Policy document (Open, Transparent and Merit-based Recruitment of Researchers) that is available in the university intranet. In 2013, the European Commission granted the University of Turku the right to use the HR Excellence in Research logo.

There are 40 academic staff members teaching in the degree programmes under review. Annual admission rates are: 120 for the Bachelor's degree program (3+2 years) and 30 for the Master's degree programme (2 years). The student-teacher ratio is acceptable. However, given the trend towards an increase in the number of students, shortage of teachers may become a problem in the future. All the more so as students are already complaining that teachers often do not have enough time to provide guidance and feedback.

According to the CVs included in the self-evaluation material, the academic staff has the required competences. The workload of staff is planned on an annual basis, in development discussions between staff and their superiors. Based on the interviews and the teaching demo sessions, the teaching staff is competent and motivated, and junior teachers are mentored by senior professors. On the other hand, only about 60% of the teaching staff have a PhD degree.

Academic staff members have personal development plans that are discussed during annual development discussions. In-house pedagogical training of teaching staff is centralized at the university and is organized by the HR development service. Teachers can complete 10, 25 or 60 ECTS modules on university pedagogy arranged by the university's Faculty of Education. The university develops and utilizes an online learning environment UTUPS (University of Turku Pedagogical Studies) for university teachers and doctoral students. However, as it turned out during interviews with the academic staff, interest in the courses is so great that it is not always possible to sign up for the course.

Pedagogical competence is considered in the recruitment of all academic staff, but pedagogical education is not a formal recruitment criterion at the university. According to a recent internal survey conducted in the Department of Computing in 2021, the overall coverage of pedagogical studies among the teaching staff is relatively high: 66 percent of teachers responding to the survey (n= 24) have completed pedagogical studies.

Academic staff is actively involved in conducting R&D projects: in the Web of Science, Core Collection there are 761 documents published by the researchers of the Department of Computing in 2016–2021, and about 20% were among the top 10 % in the research field with an average CNCI of 1.93. About half of the teaching staff has WoS h-index 10 or higher.

In general, it seems that the academic staff is open-minded and pedagogically competent: e.g., different advanced teaching methods like flipped learning were mentioned during the interviews.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 9 conditionally.

Based on the team's assessment, the Master´s degree programme meets Standard 9 conditionally.

Standard 10: An effective team of technical and administrative staff supports the programme. There are arrangements in place to keep the competence of the support staff up to date.

The support staff (both technical and administrative staff) is administratively divided into three levels: department level (about 3,2 person-years), faculty level (about 5,5 person-years) and university level (about 7,6 person-years). The persons working for the department are a financial secretary, an HR specialist and a research specialist. Education and industry cooperation are managed at the faculty level. The faculty also has a full-time education manager whose primary role is to secure the quality of the education, to develop the educational portfolio, stakeholder connections and working life relevance of the degree programmes and to support the dean in the operative and strategic management of education. Student affairs and research (including doctoral education) are mainly administered at the university level.

Staff development discussions are conducted once a year with the respective superior where competence development is one of the major topics. In these discussions, current personal training and development needs are discussed and a development plan agreed on.

The staff training of the university is guided by a university level development strategy. The training is mainly organised by university administration, according to the Staff Training Calendar, but also other options are available. For example, university staff also have access to trainings in the Wistec/Eduhouse Online learning environment and online courses.

Based on the self-evaluation material and interviews with staff and students during the site visit, an understanding was formed that the support staff is competent and efficient. On the other hand, it became obvious that there was a lack of support staff for study counselling purposes on the faculty level. The university does not have substantiated calculations on the basis of which to find the required number of support staff. For example, based on the interview with the support services staff, there are on average one thousand students per study advisor, which is clearly too much to provide adequate support for students (see also Standard 11 for more detailed description).

Based on the team's assessment, the Bachelor´s degree programme meets Standard 10 conditionally.

Based on the team's assessment, the Master´s degree programme meets Standard 10 conditionally.

Standard 11: The students are provided adequate and accessible support services to enable the achievement of the programme learning outcomes.

In general, there is a wide variety of services available, covering all the usual areas, and as seen in the interviews, evidently the support services work well to fulfil their duties and provide adequate support for students. The support services available for students are organized both at the university level as well as the faculty level. The unit of Educational Affairs at the University of Turku consists of faculty-level offices and services for student affairs and centralized services that provide support and coordination for all faculties as well as services for all students.

The available support services aimed for the students of both degree programmes can be summarized as follows:

- Student Centre Disco (centralized service): general study-related matters such as registration with the university, transcripts of studies, key cards to exam rooms as well as general admission services.
- International Office: student exchange programmes and grants; assistance and support for international students and UTU students in terms of student mobility.
- Faculty´s Office for Academic and Student Affairs: the Department of Computing has an assigned study advisor as part of the office staff. The advisor provides counselling services in common study-related matters, helps students with, e.g., study time applications, credit transfer applications and guides the students to contact other support services, such as teacher tutors, study psychologist and health care services when needed. In addition, the department has an assigned education coordinator who provides support for students and staff in study-related matters, such as graduation, study planning, study rights, degree programmes and credit transfers.
- Career Services (centralized service): career counselling and job seeking services to students.
- Study and Work Well-being Services (centralized service): different methods and practices related to the well-being of students and staff at the University of Turku. Services for students include an accessibility planning officer who guides and supports disabled students and different kinds of learners as well as study psychologists for educational psychology services and student counselling (matters such as study and learning skills, issues related to learning motivation, or learning ability and coping).

In the beginning of studies, new students have a student tutor who helps their group of new students with many study-related practicalities. In addition, part of the support services is systematic multiple online training provided by the library and tech training provided by the IT department for all the students.

According to the interviews, apparently the typical use case is that support staff members often directly help students—and not necessarily just the support staff who have direct interaction in their work description. The issue is that with the rising number of students this is probably not sustainable in the future. Based on the interviews, there seems to be a relatively low threshold for students to, e.g., email relevant support staff members and ask them directly, often getting help with administrative issues quickly and easily, in a few hours after reaching out.

There might be a need to support the objectives of these services by more frequent student surveys so the progressive service development could focus on problematic areas and be even more automated. At the moment, the support staff's knowledge on students' progress is rather indirect, as the feedback from students comes through to teaching staff members and afterwards through to the educational committees and only after that to support services. Even though the current personal approach is admirable there is a need for extending the support staff and establishing more systematic solutions.

In the interviews with the students, it was evident that diversity among the student body is growing, and this leads to the diversified and individual support needs, too. Thus, there may be a time to re-think the organizational structure to support different student types (segments) in different ways. The current mode of operations at the Department of Computing is often based on similar students with sporadic support needs only, which may not be adequate in the coming years as some student segments may need more systematic support during the student life cycle.

An interesting approach is the MyTeacher system which provides students with mentors; based on the interviews, this system is expected to play a key role in supporting students and it is also expected to provide the faculty with up-to-date information on the progress and well-being of the students. The aim is that every student has a teacher tutor appointed by the department. The teacher tutor's task is to support, help and guide the student throughout the degree and approve the student's personal study plan during the first year of studies. In Master-level studies, a similar tutoring practice is planned to continue through the role of a HOPS instructor/tutor (HOPS referring to a personal study plan). Like in Bachelor's degree studies, the role of the HOPS instructor in advanced level studies is to be aware of the student's progress throughout the degree and to support and instruct in various obstacles on the way towards the Master´s degree. According to the self-evaluation report, the practices are not uniform over all HOPS groups, but it is recommended to have regular face-to-face meetings with the student.

However, the students' experience of the MyTeacher system seems rather inconsistent. The quality of support varies a lot between one student and another (based on, e.g., whether a particular student happens to get an active, personally enthusiastic mentor). The average quality may be adequate, however the large variance is a huge concern. Some of the interviewed students—e.g., those who attend only Master's degree studies—were not even familiar with the system.

There is a need to implement a process for monitoring the MyTeacher system to ensure that it is running as intended. There should be a plan in place of what to do when there are problems. The teachers who are part of the system should also be provided enough workload and administrative support to fulfil their role. One possibility is integrating the Peppi study data system with the MyTeacher process, but the systemic challenge of too few support staff members serving a large student population persists.

The study counselling structure as a whole consists of support provided by the faculty´s study advisor and academic counselling provided by the designated teachers belonging to the MyTeacher system, along with the support provided by the centralised university level services. The current ratio of study advisors to students is 1:1000. As far as the MyTeacher system is not running as intended, the current situation is unsustainable and the whole staff workload allocated to the study counselling is to some extent unclear.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 11 conditionally.

Based on the team's assessment, the Master´s degree programme meets Standard 11 conditionally.

Standard 12: The classrooms, computing facilities, software, laboratories, workshops, libraries and associated equipment and services are sufficient and accessible to enable students to achieve the programme learning outcomes.

The site-visit included the facilities tour, where the key facilities were presented for the accreditation team. This consisted of classrooms, IT classrooms, self-study spaces, laboratories, the main library, the faculty library as well as premises reserved for the student associations of the Department of Computing. The laboratories included in the tour were the following ones: the Virtual Reality Laboratory, the Embedded Systems Laboratory as well as the TIARIS Robotics and Intelligent Systems Laboratory.

In terms of computing facilities and software, the degree programme students have IT classrooms available and they are open 24/7 for all students during their studies. All the software needed in the studies are available on the onsite computers. All software and licenses (e.g., Matlab) can also be downloaded to students' own computers and accessed online. It is noted in the self-evaluation report that as nearly all students have their own laptops separate IT classrooms are not so important in teaching nowadays. Also some of the laboratories are virtual. The Department of Computing has laptops for students to lend if needed.

As an example of the innovative equipment, the department currently has approximately 30 Lego Mindstorms, which are used in degree education mainly at the Bachelor-level. Mindstorm is a hardware and software structure which is produced by Lego for the development of programmable robots based on Lego building blocks. Lego Mindstorms can also be used for independent study.

According to the interviews, students seem mostly satisfied with the situation of study premises and materials. Especially convenient is the system of classifying study areas (e.g., in libraries) according to ”noise level”. Some laboratory spaces are also available for students' own projects and hobbies. To support students in taking advantage in all of these possibilities, students can attend many of online trainings for, e.g., ICT or library use.

As a conclusion, primarily the Department of Computing along with the degree programmes under review have the needed facilities and equipment within sufficient capacity at the moment. However, apparently the capacity before the pandemic (during the absolute in-person mode) was close to the edge of the students' needs. If the degree programmes under review even consider returning to the previous mode or significantly upscale the number of enrolled students there is a need to also upscale the facilities accordingly. To avoid this and similar problems regular surveys should take place. The last one for study facilities took place four years ago so it is very much out of date. Regular feedback loops for facilities would also help to facilitate a systematic approach in facilities and support development in general.

There are also some other areas for improvement. As discussed under Standard 8, some of the laboratories (e.g., the main IT classroom) are rather old-fashioned and their layout does not allow practicing teamwork and discussion, which may negatively affect the outcomes of studies. A more progressive approach allowing the use of modern agile development methodologies is desired; the university facilities should be flexible enough to model real-world industrial environments.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 12 fully.

Based on the team's assessment, the Master´s degree programme meets Standard 12 fully.

Standard 13: The HEI and the programme have external partnerships that are adequate to the achievement of the programme learning outcomes.

The Department of Computing has several external partnerships that make a contribution to teaching and learning and that are based on formal agreements such as EIT Digital, FiTech network, Meyer Turku, Bayer Nordics, the Allied ICT Finland, Turku Sec Information Security Association, the Finnish Software and E-business association, UAS Turku, and other local higher education institutions (Åbo Akademi university, Turku University of Applied Sciences and Novia university of Applied Science), and others. The faculty has also 14 donated professorships from local, regional and national donors.

The share of foreign universities among the partners is relatively small as we can see from the division of partners in projects of the department: companies – 27%, domestic universities – 27%, domestic universities of applied sciences – 14%, other public institutions – 12%, foreign universities – 9%, research institutes – 9%, foundations and associations – 2%. By far the biggest number of partners in projects is in the Communication and Cyber Security track. It is interesting to note that there are almost 7 times fewer partners in the Smart Systems track, but approximately the same amount of supplementary income is generated.

Students can take courses at other local higher-education institutions without any additional formal registration procedures, which is seen as an asset by the accreditation team.

At the same time, the accreditation team sees three major areas of improvement in this field:

Acquisition of experience used in real professional activities. The tool for this would be to better integrate business and industry internships in the teaching and learning process. At the same time, it would also include a number of other activities, such as the wider involvement of top specialists in companies in the educational activities and the design of computer classes that would enable the application of development methodologies used in companies.

Cooperation with external stakeholders is extensive, but relatively unsystematic. For example, several stakeholders mentioned in the interview that they had not had a similar meeting to discuss the degree programmes at the university before, and they appreciated the opportunity to discuss, provide feedback and voice their concerns and recommendations. Systematic cooperation with the stakeholders was also mentioned to be one of the areas in need of development in the self-evaluation report.

The visibility of the competences and activities of the Department of Computing is relatively low: external stakeholders and the wider public are not sufficiently informed about the competencies and cooperation opportunities related to the department.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 13 fully.

Based on the team's assessment, the Master´s degree programme meets Standard 13 fully.

Standard 14: The financial resources are sufficient to implement the learning process as planned and to further develop it.

The Department of Computing has its own budget, which is divided into parts: basic/core funding (allocated to the university by the Ministry of Education and Culture) and supplementary funding (from the Academy of Finland, Business Finland, foundations, enterprises, the European Union and other sources). The budget is determined by the Faculty Council in accordance with the normal budgeting procedure. Basic funding of the department has remained approximately on the same level over the past six years (around 4,25M€ in

2016 and 4,3M€ in 2021). Supplementary funding is more volatile but tends to increase overall (around 4,76M€ in 2016 and 5,33M€ in 2021). However, the budget allocated to the needs of the degree programmes has a decreasing trend, from 5,85M€ in 2016 to 4,65M€ in 2021. This was mainly due to a decrease in basic funding of almost 30% during this period. The biggest amount of supplementary funding in 2021 came from the Academy of Finland (around 1,8M€), followed by Business Finland (around 1,2M€) and Ministry of Education and Culture (around 0,9M€); EU-funding was relatively small (less than 0,8M€).

The decline in funding is clearly reflected in the number of academic and support staff, which does not increase in proportion to the number of students.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 14 fully.

Based on the team's assessment, the Master´s degree programme meets Standard 14 fully.

Strengths, good practice and areas for further development regarding section 2.3: resources

The team notes the following strengths and good practice in this section:

17. Both the teaching staff and the support staff seem to be competent and motivated, and there are mechanisms in place that support the career development of the staff members.
18. There is a low threshold for students to ask for and receive help.
19. Students also benefit from the study opportunities provided by the other local higher-education institutions.

The team sees the following as areas for further development in this section:

20. Ensuring that there are sufficient resources (funding, teachers, support staff, and facilities) also in the future, especially given the growth in student volumes.
21. Ensuring that the MyTeacher system runs as intended, supporting and motivating the teachers, monitoring the system, and planning how to react to problems.
22. Integrating external stakeholders better in the planning and implementation of teaching.

2.4 Quality management

Standard 15: The quality management procedures of the programme are consistent with the quality policy of the higher education institution.

The university's quality system and the principles for its development are described in detail in the Quality Manual, which was included in the self-evaluation material. The Quality Policy approved by the university board summarises the principles of the university's quality work as follows:

"The University of Turku creates prerequisites for high-quality and innovative operations, maintains and develops a strong operational culture and provides efficient and expert services to support the university's basic missions. The university-level steering with clear processes and quality management that covers the entire operations are part of the quality system. The purpose of the quality system is to ensure quality as well as to develop quality. The entire university community participates in the continuous development of high-quality operations as a natural part of their work and activities."

The university has also defined the following institutional goals for quality work:

- *realising the university's mission statement*
- *promoting the university's strategy and policy programmes,*
- *the quality and societal relevance of research and education,*
- *developing the university's competitiveness nationally and internationally and*
- *maintaining high quality in practical work.*

As explained in the self-evaluation report, the university's quality policy steers the degree programmes indirectly via several constructs, principles and activities. Some of those are stated by the university in the University of Turku Rules of Procedure, and others are stated at the faculty level and indirectly at the department and degree programme level.

Furthermore, the university has defined responsible bodies for all levels of the institutions that take care of the steering of education as well as its quality management. The rector of the university is responsible for quality work as a whole, and the units' management of quality work at their respective units. At the university level this is carried out by the Teaching and Learning Council, at the faculty level by the Committee for Undergraduate Education Development and Faculty Board and at the department level by the Committee for Undergraduate Education development as well as degree programme level steering groups. Therefore, the degree programmes under review have relevant responsible bodies for handling the quality of education as well as its quality management.

The degree programmes under review have identified the following key practices and principles when implementing the institutional quality policy on the degree programme level in the development of education:

- *Bi-annual curricula development activity*. At the faculty and department levels, the activity is managed by the vice dean and the department vice heads. The key definitional elements of the process are curriculum letters written by the vice rector and the vice dean for education. The dean's letter defines the main development aspects, expectations on outcomes, the roles of a broad set of actors, and for example the timetable for the process lasting one whole academic year. The faculty study administration and the departments then specify these instructions as coordinated actions, which are implemented by the departments and monitored by committees and responsible leaders.
- *The teachers´ responsibility for the quality of their own education and for the continuous development of degree education.* The teachers are supported in this by the university by a dedicated education development team and materials provided on the university intranet as well as pedagogical training as an in-house activity.
- *Participation of external stakeholders in the curriculum work.* A specific method for the engagement of external stakeholders in curriculum work is engagement through programme level steering groups.
- T*he student participation in monitoring and assessing the quality of education.* Students participate by providing feedback through a course feedback system and by participating in different educational development groups. The students are represented in all formal committees at the university, faculty and department levels, which provides the degree programmes with continuous informal and formal student feedback.

As explained in the self-evaluation report, as a whole on the university level external stakeholders engage in many ways in the development of activities, e.g., by participating in decision-making, in strategy work and annual planning, and by participating in externally funded research and development projects. However, at the time of the site visit the Faculty of Technology did not yet have an operational external faculty board, but it was planned to be established later in 2022. Thus, the systematic engagement of the external stakeholders into the quality management at the faculty and degree programme level seems currently be under on-going development and not fully mature yet.

Based on the self-evaluation report as well as interviews with the management, teaching staff and support staff, the degree programmes apply the institutional quality policy and quality work practices as they are supposed. The overall impression is that there is a good drive to make quality management happen in the Faculty of Technology as well as in the Department of Computing, but there are a couple of concerns also in the quality management when it comes to coping with the fast growth of the degree programmes under review. The resourcing for teaching and support staff as well as the supporting processes seem to be lagging with the increasing amount of students. Also, the external stakeholder involvement in improving the curriculum could benefit from a more effective and systematic approach.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 15 fully.

Based on the team's assessment, the Master´s degree programme meets Standard 15 fully.

Standard 16: The organisation and decision-making processes of the programme are fit for effective management.

Based on the self-evaluation materials as well as information in the university´s intranet, the university along with the Faculty of Technology, Department of Computing as well as the degree programmes under review have clearly defined decision-making structures and responsibilities. The self-evaluation material included examples of the minutes of the decision-making bodies´ meetings, which were examined by the accreditation team.

The university's decision-making in educational affairs is decentralised, and the faculties are responsible for most issues related to degree education. For example, the faculties decide on the student selection criteria, admit the students, approve the curricula, evaluate and develop the degrees and studies related to the degrees, and decide on general arrangements related to course completion. The university board decides annually on the number of degree students to be admitted to the university based on the proposals sent by the faculties. The departments and subjects are responsible for the practical organisation of education and for academic study guidance. The degree programmes' operative management and development is done by the department board and by research labs, which manage human and other resources. In addition to staff members, also the students of the Faculty of Technology participate in the formal decision-making at the faculty. As explained in the self-evaluation report, in line with the Finnish traditions of university governance, there is always representation by the students in all decision-making and planning level bodies. In addition, a majority of the faculty committees have student representatives.

The responsible leaders of the degree programmes and majors mainly manage the content as part of the curriculum development process together with their curriculum development groups and steering groups but decisions on the actual content of the degree programmes are made by the faculty board. Operational decision making is done by the department head and vice heads.

The decision-making process did not seem to bring up any issues in the stakeholder interviews nor in the student or alumni interviews. However, in the management interview the idea of effective management was not crystal clear to participants. The accreditation team considers that it might make sense to explicitly try to define it, and then develop metrics for monitoring it.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 16 fully.

Based on the team's assessment, the Master´s degree programme meets Standard 16 fully.

Standard 17: The programme reviews and develops the programme aims, curriculum, teaching and learning process, resources and partnerships and quality management in a systematic and regular manner, taking into account analysis of results of student admissions, students' study progress, achieved learning levels, student, graduate and employer feedback and graduate's employment data.

Both degree programmes conduct regular reviews for development purposes. The review system is a university-wide self-evaluation concept and implemented accordingly at the department level. On top of national surveys, the Department of Computing composes annual self-evaluations of degree programmes where, according to the newly (in 2022) introduced form, the programme aims (both qualitative and quantitative), assessment of aims achieved, strengths and development needs, the management structure of the programme, students' engagement in planning and implementing the education, and the working life relevance and societal impact of the degree programmes are addressed. Self-evaluation bases heavily on feedback data collected from students, teachers, graduates and employers, as well as on data from the university information system on student admissions, students' study progress, international mobility, success rates and time taken to complete the degree programmes. The self-evaluation reports are discussed at the Faculty Committee for Undergraduate Education Development for further analysis and actions.

The degree programmes follow the generic guidelines for feedback collection used at the university. The Department of Computing uses a compulsory course feedback system. Each course has been required to collect feedback during each period since autumn 2019. Teachers can collect the course feedback by different methods. Teachers can use a ready-made template prepared by the department's Committee for Undergraduate Education Development. The joint template contains five questions prepared and agreed to by the university's teaching and learning council. In addition to the formal course feedback questionnaire, teachers typically collect also other student feedback during the courses.

The questionnaires focus on evaluating the quality of the courses rather than the degree programme as a whole. In general, the student feedback system works well when it comes to individual courses. The accreditation team recommends expanding this by collecting stakeholder feedback on a regular basis for the entire curriculum.

In addition to the course feedback, the degree programmes take part in the following national and institutional surveys:

- *The annual national survey targeted at the first-year students*. The survey collects feedback on student experiences at large, teaching and learning and student life in general.
- *The national university feedback survey, which collects feedback from all Bachelor's degree graduates*. The survey is coordinated by UNIFI and the results across universities are published by the Finnish National Agency for Education. The survey collects feedback on study content but also on the learning process and support services during degree studies.
- *The university´s recruitment services follow the student feedback on practical placements through the formal practical placement system and the connected feedback survey targeted to students and employers.*

- *The Academic Engineers and Architects in Finland TEK's annual Graduate Survey.* In the TEK Graduate survey, e.g., work experience during the studies and the importance of work experience are surveyed.
- *The university collects feedback on international mobility from in-coming students.* A feedback survey is sent to all in-coming students before their mobility period ends. The survey includes a thorough set of questions concerning both course offering, guidance and instruction concerning studies and support services.

While asking for feedback from students and alumni is systematic, feedback from teachers and employers is relatively unsystematic. The unsystematic manner of collecting employer feedback is also noted in the self-evaluation report.

The response rate of graduates is very high (up to 90%) while the response rate of students is sometimes relatively low. Interviewed students claimed that they do not know how their feedback matters and how it will influence the degree programmes. This may also decrease the motivation to provide feedback. The accreditation team recommends increasing the visibility of the development actions taken based on the student feedback.

There are procedures in place to collect general data on the progress of studies. The Faculty of Technology as well as the Department of Computing primarily follow the institutional practises in ways of collecting the progress data. Study statistics at the university are compiled at the unit of Student Support Services and it is done for each calendar year. The statistics are publicly available on the UTU web site. The statistics include the number of applicants and applications to the university, the number of students in different faculties and degree programmes, the number of degrees completed, and the number of credits completed (per faculty, per department and degree programme, per subject etc.). Also, the numbers of credits completed in different study units (courses) are listed. Self-evaluation material also include examples of the progress data, which are stored in the electronic Sea File system for the university´s internal use.

However, as a whole the monitoring of students' study progress relays on a number of solutions and activities in use:

- Peppi study data system
- a collaborative learning platform VILLE, developed by the Centre of Learning Analytics of the University of Turku,
- the MyTeacher system
- TOHKE activity for following and steering the degree programmes, launched in 2021 by the Faculty of Technology
- a personal study plan (HOPS) instructor for the students of both degree programmes under review

The accreditation team considers that currently all these procedures are not properly integrated with each other, nor with the electronic feedback system. Although the MyTeacher system and HOPS are supposed to monitor students' learning based on real-time data, they don't actually work as they should. The accreditation team recommends integrating diverse information systems and processes better so that the degree programme management has accurate and up-to-date operational data and gets early warnings when the key processes are not working as intended.

Based on the team's assessment, the Bachelor´s degree programme meets Standard 17 fully.

Based on the team's assessment, the Master´s degree programme meets Standard 17 fully.

Standard 18: The programme provides public, up to date information about its objectives, teaching and learning process, resources, quality management procedures and results.

The degree programmes provide public information about the curriculum and its results based on need-to-know bases. Feedback about the courses is shared only within the curriculum management bodies. The university also provides links to university database reports for community members only.

Generic information about the curriculum, administration and the results are shared in public. Student application and selection results are provided by the nation-wide student administration (the national applicant and study right register). The amount of student exchange and the number of credits (both from degree studies and pen university studies) are provided by the university system.

The UTU web site also provides links to common statistics about universities (Vipunen and Statistics Finland). The material is not edited, but the user needs to search for the results of the University of Turku by herself. Vipunen provides statistics and indicators for education in a number of educational sectors, placement of students after completion, research conducted in higher education institutions, the population's educational structure and the socio-economic background of students. Statistics Finland provides national statistics from all sectors and themes.

The university provides the results broadly in Finnish, but the amount of English material is limited. The web site includes timetables of the publishing dates of statistics for the users to be aware of updates of results. As the university has limited access to the real-time progress of the studies and courses, there are no real-time results available in public. The updates are provided mostly once a year (semester results are an exception).

Based on the team's assessment, the Bachelor´s degree programme meets Standard 18 fully.

Based on the team's assessment, the Master´s degree programme meets Standard 18 fully.

Strengths, good practice and areas for further development regarding section 2.4: quality management

The team notes the following strengths and good practice in this section:

- The degree programmes make active use of a number of surveys, self-evaluations, and reports to monitor and develop the curricula as well as teaching and learning success.
- There is an extensive quality manual for the university, along with the degree programmes.

The team sees the following as areas for further development in this section:

- Integrating diverse information systems, operative processes, and management processes better with each other so that the degree programme management has accurate and up-to-date operational data and gets early warnings when the key processes are not working as intended.

3

Overall evaluation of the degree programmes

3

Bachelor's degree programme

Upon reviewing the programme the team highlights the following **key strengths and good practice**:

- The degree programme has a clear engineering profile, with an emphasis on problem-solving and product-development skills.
- The degree programme manages to achieve its main goals well: it produces engineers with the right problem-solving mind set, with strong programming skills, and who are eager to learn more.
- The degree programme builds a solid foundation for understanding the principles of computing by going all the way to the low-level details of computing hardware and electronics.
- Both the teaching staff and the support staff seem to be competent and motivated, and there are mechanisms in place that support the career development of the staff members.
- The degree programme makes active use of a number of surveys, self-evaluations, and reports to monitor and develop the curricula as well as teaching and learning success.

The team sees the following as **main areas for further development** of the programme:

- Clarifying the independent role of the Bachelor's degree programme.
- Ensuring that students acquire sufficient non-technical multidisciplinary competences and work-life skills.
- Providing more opportunities for project-type assignments in which students solve practical computing problems.
- Making better use of the large amount of physics studied in the degree programme.
- Reducing variance in the quality of implementation between different courses.

- Ensuring that there are sufficient resources also in the future, especially given the growth in student volumes.
- Ensuring that the MyTeacher system runs as intended.
- Integrating external stakeholders better in the planning and implementation of teaching.
- Integrating diverse information systems, operative processes, and management processes better with each other so that the degree programme management has accurate and up-to-date operational data and gets early warnings when the key processes are not working as intended.

The team recommends that the degree programme is accredited with the following conditions

- Revise the description of the programme aims so that they make clear the independent role of the Bachelor's degree programme as a programme that does not just prepare students for Master's studies (standard 1).
- Revise the programme-level learning outcomes to ensure sufficient coverage of non-technical multidisciplinary competences (standard 2).
- Revise the course-level learning outcomes to ensure sufficient coverage of non-technical multidisciplinary competences (standard 3).
- Prepare a concrete plan for ensuring that students acquire sufficient work-life skills and non-technical multidisciplinary competences (standard 8).
- Prepare a concrete plan for ensuring there are sufficient teaching resources available also in the future, even with the growing and more diverse student population (standard 9).
- Prepare a concrete plan for ensuring there are sufficient support staff resources available also in the future, even with the growing and more diverse student population (standard 10).
- Perform a root-cause analysis of the failure of the MyTeacher system. Fix the system so that it runs as intended for all students. Implement a process for monitoring the system in the long term (standard 11).

Master's degree programme

Upon reviewing the programme, the team highlights the following **key strengths and good practice**:

- The degree programme has a clear engineering profile, with an emphasis on problem-solving and product-development skills.
- The degree programme manages to achieve well its main goals: it produces engineers, with the right problem-solving mind set, with strong programming skills, and who are eager to learn more.
- There are several high-quality Master-level courses with advanced content, and in particular the "Capstone" course is often mentioned as a highlight of the degree programme.

- Both the teaching staff and the support staff seem to be competent and motivated, and there are mechanisms in place that support the career development of the staff members.
- The degree programme makes active use of a number of surveys, self-evaluations, and reports to monitor and develop the curricula as well as teaching and learning success.

The team sees the following as **main areas for further development** of the programme:

- Unifying the way in which the learning outcomes of the three tracks of the Master's degree programme are described and presented.
- Ensuring that students acquire sufficient non-technical multidisciplinary competences and work-life skills.
- Implementing more extensive horizontal sharing of experiences between students.
- Reducing variance in the quality of implementation between different courses.
- Ensuring that there are sufficient resources (funding, teachers, support staff, and facilities) also in the future, especially given the growth in student volumes.
- Ensuring that the MyTeacher system runs as intended.
- Integrating external stakeholders better in the planning and implementation of teaching.
- Integrating diverse information systems, operative processes, and management processes better with each other so that the degree programme management has accurate and up-to-date operational data and gets early warnings when the key processes are not working as intended.

The team recommends that the degree programme is accredited with the following conditions

- Unify the descriptions of the programme-level learning outcomes of the three tracks so that it is clear what is common to all three tracks and what is unique to each track. Revise the programme-level learning outcomes to ensure sufficient coverage of non-technical multidisciplinary competences (standard 2).
- Revise the course-level learning outcomes to ensure sufficient coverage of non-technical multidisciplinary competences (standard 3).
- Prepare a concrete plan for ensuring that students acquire sufficient work-life skills and non-technical multidisciplinary competences (standard 8).
- Prepare a concrete plan for ensuring there are sufficient teaching resources available also in the future, even with the growing and more diverse student population (standard 9).
- Prepare a concrete plan for ensuring there are sufficient support staff resources available also in the future, even with the growing and more diverse student population (standard 10).
- Perform a root-cause analysis of the failure of the MyTeacher system. Fix the system so that it runs as intended for all students. Implement a process for monitoring the system in the long term (standard 11).

4

Decisions of the FINEEC Committee for Engineering Education

4

In its meeting on 8 September 2022 the FINEEC Committee for Engineering Education decided, based on the proposals and report of the accreditation team, that the Bachelor´s degree programme in Information and Communication Technology and Master´s degree programme in Information and Communication Technology are both accredited conditionally. The accreditation of the master´s degree programme covers the following tracks of the programme:

- Software Engineering (SE)
- Smart Systems (SS)
- Communication and Cyber Security Engineering (CSE)

The set conditions are those listed in section 3. The accreditations are valid until 8 September 2023 by which the University of Turku should report to the Finnish Education Evaluation Centre on how they have met the set conditions. If the FINEEC Committee for Engineering Education then finds that the conditions have been successfully met, the validity of the accreditations will be extended until 8 September 2028.

Engineering programme accreditation is a degree programme specific evaluation that can lead to the European EUR-ACE® Label. The accreditation aims to support the enhancement of quality in engineering degree programmes and increase the international comparability and recognition of engineering degrees within Europe. The accreditation is voluntary for Finnish higher education institutions and degree programmes.

This report presents the process and results of the accreditations of the engineering degree programmes in Information and Communication Technology at the University of Turku in Finland. FINEEC has carried out engineering degree programme accreditations since 2014 at the Finnish universities of applied sciences. FINEEC is authorized by ENAEE to award the EUR-ACE labels to the 4-year degree programmes of 240 ECTS. To extend its mandate to the 3-year and 2-year degree programmes, FINEEC carries out pilot accreditations in 2022–2023. These accreditations are part of this piloting phase.

The Finnish Education Evaluation Centre (FINEEC) is an independent agency responsible for the evaluation of education. It operates as a separate unit within the Finnish National Agency for Education. It implements system and thematic evaluations, learning outcome evaluations and field-specific evaluations. Moreover, FINEEC supports providers of education and training and higher education institutions in matters related to evaluation and quality assurance, as well as advances the evaluation of education.

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