QUALITY ASSURANCE IN ELECTRONICS-ICT ENGINEERING EDUCATION

Jo Verhaevert

Ghent University - imec, IDLab, Department of Information Technology (INTEC),
Technologiepark-Zwijnaarde 126, 9052 Ghent, Belgium

ABSTRACT

This paper outlines a system of internal quality assurance and its concomitant education support services for the teaching staff and study programme committee of the electronics-ICT engineering education at the faculty of Engineering and Architecture of Ghent University. Living up to the Ghent University credo 'Dare to Think', this system is a fully-fledged quality culture, in which all stakeholders naturally strive for continuous quality assurance as well as quality enhancement. It offers information on our study programme's unique selling points and on its strengths and weaknesses with regard to quality assurance.

Our study programme carries out annually a critical self-reflection on the following two features: programme-specific content and quality culture, meanwhile explicitly following the CDIO guidelines. The responsibility lies with our programme committee, also in charge of generating and cultivating the engagement of all relevant stakeholders: students, lecturing staff, professional field, alumni, international peers and experts. Since in the new system the programme-specific content plays a more important role, guidelines to facilitate embedding the external perspective are developed. Quality performance tools are essential to promote a qualitative and systematic reflection process. Therefore, an education monitor is used as a team site and document management system. A manageable set of programme-specific operational objectives have been integrated into this education monitor, are easy to assess and linked to the data made available through our business intelligence system. This education monitor is data-driven, with a proper dashboard function. In summary, the above-mentioned quality performance tools enable us to draw up an annual quality improvement plan. In this paper, all parts of the quality assurance system are described, supported by the CDIO standard programme evaluation.

KEYWORDS

Quality Assurance, Programme Evaluation, Standards: 1, 10, 12

INTRODUCTION

The improvement of quality by higher education institutions is not only important for the optimisation of the limited financial resources, but also as a responsibility of educating future professionals in a high-quality way. The electronics-ICT engineering study programme educates people who dare to think about tomorrow's challenges. In order to assure the quality,

an attitude of data-driven critical reflection and systematic follow-up of improvement actions is installed. It consists of the implementation of monitoring instruments that will enhance quality reflection. This quality assurance system is built on four principles:

- trust in the expertise held by all courses of our study programme;
- shared ownership by facilitating and stimulating self-management. After all, all courses of our study programme are the principal engine for generating and monitoring quality;
- continuous improvement by furthering a positive quality culture, in which our study programme is stimulated to continuously improve (the quality of) our education;
- by offering a set of efficient 'quality performance tools', the existing quality assurance procedures is supported and policy-making is substantiated.

We focus on systematic quality reflection on our education policy. It is based on the PDCA-circle (Plan-Do-Check-Act) of Shewhart and Deming (1939): establishing objectives (Plan), carrying out them (Do), gathering data and results (Check) and improving the process (Act), restarting the entire circle. This reflection results in appropriate improvement measures on the level of individual lecturers and study programme (committee), augmenting the overall quality.

In this paper, the previous and the actual Ghent University system are described, followed by the implementation within the electronics-ICT study programme. A next section discusses the critical view by externals. The section thereafter handles the lessons learned on the implementation of this system on continuous quality culture. The last section finalises with the conclusions.

GHENT UNIVERSITY SYSTEM

In this section, the change in quality assurance and enhancement at Ghent University is described. We will start with a short description of the old system: portfolio, which is followed by an extensive description of the new system: education monitor, based on both a data-driven critical self-evaluation and a quality improvement plan.

Old System: Portfolio

For many years, the quality of higher education institutes was validated by accreditation bodies, organised by the Flemish government. The development of such accreditation bodies, national or international, tried to ensure that quality was in place. However, the focus was most of the time on quality assurance and not on feedback and putting important steps on improvement. Therefore, all participants saw this as an obliged process with a restricted outcome: a list of quality criteria obtained positive (or negative) checks, but with no indication for quality enhancement. It also resulted in lengthy documents including as much information as possible.

A decade ago the government transferred the quality assurance to the higher education institutes themselves. At that time Ghent University installed a different monitoring process: at

study programme level, at faculty level and at the level of rectorate. The accreditation bodies remained responsible for checking if all higher education institutes were in control of all quality.

At that time, we used for every study programme a digital portfolio, as an online repository and giving a complete view on every aspect of the study programme. The main part was the description of the vision and operationalisation, as a translation of the different learning outcomes (Verhaevert & Van Torre, 2019). It also consisted of an overview of the continuous approach to assure quality within the own study programme. It also gave a description of the day-by-day processes and practices of the internal of the study programme. This digital portfolio formed the basis for peer learning visits by other study programme leaders. The focus was on the exchange of best practices across disciplinary boundaries and on learning from each other. The written report serves as a proof that the own institution is in control of the quality.

When implementing this system, also major drawbacks appeared: the evaluation of 55 processes and more than 100 indicators resulted in an unclear view and a too static instrument. Although the peer learning visits focused on learning from each other, the overall feeling was that scores by the peers in the written report resulted too much in window dressing and that the entire process was very time-consuming. Preparing the portfolio itself and writing a report afterwards take up a great deal of time.

New System: Education Monitor

Taking all the experiences above into account, a new Ghent University quality assurance system has been developed, called the education monitor. The focus is now on the systematic self-evaluation. It is based on the PDCA-principle, as an iterative management method used for continuous quality enhancement. First, opportunities are recognised (Plan), changes are tested (Do) and test results are analysed (Check) and, finally, actions are taken (Act) and it is started over again. It results in adequate improvement actions at different levels: the teacher, the study programme, the faculty and the higher education institute itself. All 4 levels are handled below.

- The teacher has an attitude to critically reflect on the own teaching and evaluation, based on the annual course feedback given by all students. In order to support and to encourage this reflection, several initiatives on further professionalisation are available (e.g. individual and classroom training offers, online tutorials...).
- The study programme performs at least annually a critical self-evaluation. The study programme takes the input of other stakeholders into account: students, lecturing staff, professional field, alumni, international peers and experts. The focus is on the check of the programme-specific content, based on a clear set of guidelines to facilitate the embedded external perspective.
  At the level of study programme, a set of 39 different operational objectives are defined. As a dashboard function, every objective is directly coupled with one or more inputs of the business intelligence system, making the education monitor entirely data-drive.
  To improve the quality and the systematic of this reflection process, some quality performance tools are used: the education monitor as a data-driven document management system, which is based on Microsoft SharePoint acting as dashboard. This monitor contains several small operational goals at study programme level. The business intelligence

system is entirely integrated in the education monitor. The entire self-reflection on a PDCA-cycle results in an annual quality improvement plan.

- The faculty is a key-player in the education support and the monitoring of the education quality assurance. At faculty level 28 operational objectives are defined and also here SharePoint is used (with coupling possibilities with the study programme monitors). The faculty board carries out an annual critical self-reflection based on a PDCA-cycle. Afterwards, a constructive consultation is held between faculty members and members of the rectorate. In that meeting feedback and feed-forward in both directions are discussed.
- The rectorate focuses on the attitude of an annual critical reflection, based on university-wide education policy, the general quality assurance culture and several operational goals. From a helicopter perspective, the quality assurance culture is monitored and secured. It is now based on trust and the focus is on having a clear view on the actual quality assurance and the ability of improvement, rather than a critical view of externals (which will be discussed further in this paper).

The whole process at all 4 levels results is visualised on a public web page. It describes the main strengths and weaknesses, opportunities and threats of each study programme, in combination with a realistic timing when the bottlenecks will be eliminated.

In the education monitor the study programme reflects on a regular basis all operational objectives: which objectives are acquired and which ones need to be improved. The education monitor consists of 3 major parts. In part one the study programme's vision, mission statement and context are commented. Here the learning outcomes, the curriculum and the assessment are monitored and if required, concrete improvement actions are scheduled. In part two the policy on quality assurance is discussed. Part 3 is for the Ghent University strategic education objectives, partly overlapping with parts 1 and 2. It contains the following university-wide objectives: 'Dare to Think' and 'Multiperspectivism', education based on excellent research, internationalisation of students and lecturers in the study programme, staff and student talent development and stakeholder participation. All items are analysed as a PDCA-cycle:

- Plan: For every item concrete objectives are established and described in order to deliver the required results.
- Do: The objectives described above are carried out, divided in several steps and described here.
- Check: In the Check phase, from the business intelligence system the most recent data, together with an evolution over the years, are directly fed into this lemma. If necessary, also own indicators can be added. It is followed by a reflection and evaluation on the obtained results, gathered from the Do phase. The result of every indicator is colour coded: red (insufficient), yellow (sufficient), green (good) and blue (excellent).
- Act: Depending on the obtained results in the Check phase, improvement actions are defined and followed up after different loops. It is in this phase that the overall quality of the study programme is improved, supported by the Do and Check phase above.

IMPLEMENTATION IN ELECTRONICS-ICT

The old system with the portfolio gave an entire intersection of the study programme: from vision to implementation, combined with the way the quality was assured. It resulted in a document of more than 100 pages. It was not only an extensive task to define the important parameters and to acquire all correct information, but it was also very time-consuming to keep the portfolio up-to-date. A rather small, but necessary change in the study programme resulted in changes in the portfolio on several places. The overall feeling was hence almost avoiding that change.

The education monitor as a new system of quality assurance was welcomed within the study programme Electronics-ICT. Microsoft SharePoint as a dashboard platform is more user-oriented, is more convenient and straightforward to change items and to keep track of all these changes. Because of the clustering of the different goals, less data is required. It results in a very focused and hence short set of documents, which is very convenient. It is also less time-consuming to write and keep up-to-date, compared to the former portfolio. The direct coupling with the Ghent University business intelligence system makes the education monitor truly data-driven and it is very obvious to include all relevant data to assure quality. Unfortunately there is no easy way to transfer the existing data from the portfolio to the education monitor. But we saw this fact as an opportunity to reorganise and to restructure all relevant information and to make everything more straightforward.

In order to start this process, the programme leader clustered all objectives in 6 different collections. Mixed working groups are formed: lecturing staff in charge of several courses (as core members) are put together with lecturing staff only teaching one course, with technical staff and students. The working group chair was selected/appointed to have a limited direct connection with the study programme, resulting in a fresh outsider view on the study programme. Every working group was asked to extensively discuss one collection of objectives. As input for the discussion the data (student and lecturer survey results, enrollment numbers...) from the Ghent University business intelligence system was used. The working group chair was asked to report by providing the required texts for the education monitor and to couple it via live links to the latest available data of the Ghent University business intelligence system.

All documents were discussed within the study programme committee, where all working group chairs and most of the core members were present. This resulted in a combination of documents giving a complete and correct helicopter view on the entire study programme. It also resulted in a quality improvement plan, combined with an accurate timing. Thanks to the implementation within Microsoft SharePoint, it is very convenient to extract relevant documents as input for a discussion.

Every year when new survey results and enrollment numbers are available, the education monitor needs to be updated. At the same time, the quality improvement plan with timing is also actualised: some items are in-control and can be checked, where some new items need to be added. The education monitor combined with the quality improvement plan acts as a dashboard for the education policy at study programme level and makes it very convenient to detect the strengths and weaknesses.

Table 1. CDIO Programme Evaluation

#	Standard	Score
1	Adoption of the principle that product, process, and system lifecycle development and deployment – Conceiving, Designing, Implementing and Operating – are the context for engineering education	5/5
2	Specific, detailed learning outcomes for personal and interpersonal skills, and product, process, and system building skills, as well as disciplinary knowledge, consistent with programme goals and validated by programme stakeholders	5/5
3	A curriculum designed with mutually supporting disciplinary courses, with an explicit plan to integrate personal and interpersonal skills, and product, process, and system building skills	4/5
4	An introductory course that provides the framework for engineering practice in product, process, and system building, and introduces essential personal and interpersonal skills	4/5
5	A curriculum that includes two or more design-implement experiences, including one at a basic level and one at an advanced level	5/5
6	Engineering workspaces and laboratories that support and encourage hands-on learning of product, process, and system building, disciplinary knowledge, and social learning	5/5
7	Integrated learning experiences that lead to the acquisition of disciplinary knowledge, as well as personal and interpersonal skills, and product, process, and system building skills	5/5
8	Teaching and learning based on active experiential learning methods	4/5
9	Actions that enhance faculty competence in personal and interpersonal skills, and product, process, and system building skills	4/5
10	Actions that enhance faculty competence in providing integrated learning experiences, in using active experiential learning methods, and in assessing student learning	5/5
11	Assessment of student learning in personal and interpersonal skills, and product, process, and system building skills, as well as in disciplinary knowledge	5/5
12	A system that evaluates programs against these twelve standards, and provides feedback to students, faculty, and other stakeholders for the purposes of continuous improvement	5/5

CDIO Programme Evaluation

The CDIO initiative also suggests a quality assurance and quality enhancement based on Standard 12 - Programme Evaluation. This Standard evaluates the study programme on 12 CDIO criteria and gives feedback to all stakeholders (faculty members, lecturing staff, students...) (Kontio, 2016).

When discussing the study programme and when filling the education monitor, we also performed a CDIO self-evaluation at the same time. The survey results available in our business intelligence system were very helpful and resulted in the scoring on the different CDIO standards as can be seen in Table 1 (CDIO Standards 2.0, 2022). All these standards gave us input for the discussion, while keeping the focus on enhancing the quality of the educational programme for the engineers of the future. In contrast, the education monitor - as a quality assurance system - is made available for many different study programmes of Ghent University and is indeed very general. Hence although the format is different, we can conclude that in the study programme of electronics-ICT engineering the same strengths and weaknesses appear, compared to the earlier described education monitor.

CRITICAL VIEW BY EXTERNALS

The self-evaluation described earlier in this paper is used in a learn-and-inspire way by an extensive and critical view by externals (Bennedsen & Schrey-Niemenmaa, 2016), (Kontio, 2016), including the broad community of engineering educators from around the world.

Within the CDIO framework a critical view by externals is not directly required or strongly encouraged. However, in the CDIO community experiences on improving engineering education are shared during e.g. international CDIO conferences. As is described in Clark, Thomson, Kontio, Roslöf, and Steinby (2016), Bennedsen and Schrey-Niemenmaa (2016), Kontio (2016), McCartan, Hermon, Georgsson, Björklund, and Pettersson (2016) and Rouvrais, Audunsson, Saemundsdottir, Landrac, and Lassudrie (2016), institutions of higher education are working closely to share all kinds of information of self-evaluation, cross-evaluation and critical friendship during site-visits focusing on enhancement of quality.

The goal of the set of actions accords with 3 different criteria:

- Each study programme checks the content component to the broad community of external stakeholders: the professional field, alumni and international peers. At least the learning objectives, the assessment and the exit level are analysed.
- The study programme committee discusses annually the programme-specific survey results of the professional field or other structurally involved stakeholders. Also the surveys of recently graduated students and alumni are reviewed by them.
- Every 4 years (or in the context of a curriculum revision) a programme review is carried out by at least 3 international, independent, academic peers as international authorities with a broad view on the study programme.

The different external stakeholders provide another perspective and expertise. Selecting them needs to be done carefully in order to obtain at the same time a broad and deep view:

- Regional versus international: the professional field combined with alumni mostly give an anchoring at regional level, whereas peers from other higher education institutes give an international view.
- Job market versus academia: the perspective on the job market is given by the professional field. They can import information on the employability and professional aptitude of the graduates, whereas academia members mostly focus on the academics.
- Feedback versus programme review: Collection of feedback in a structural way by the professional field and alumni is expected. In contrast, international experts are in charge of a thorough content-based programme review and of checking if the entire curriculum is sufficiently evidence-based.

For the critical view on the electronics-ICT curriculum by externals, we proposed the following:

- We established a committee with different external stakeholders. This advisory board contains all kinds of members from the professional field, mostly graduated several decades ago. They can draw attention on professional trends and on strengths and weaknesses of recently graduates. They meet annually and discuss one or more topics on quality assurance. We also organise an alumni event, where both alumni and advisory board members are present. There are presentations of the recent changes in the study programme and about an attractive and interesting topic by one of our graduates (e.g. the new DAB+ broadcast network in Flanders). All present lecturers and the advisory board members meet afterwards at a network reception for an informal chat. In the near future a more structural and formal survey is planned.
- Every master thesis in the electronics-ICT study programme is obliged to have a direct connection with the industry or non-profit organisation. It can be as follows: (partly) supervision by an industry member, advice for valorisation or evaluation, delivering use-case or data and/or as jury member for assessment. Students get hence acquainted with industry-relevant research questions and the study programme also acquires input of the professional competence and employability.
- Internships of students are partly supervised by an internal promotor and partly by an industry member as internship mentor. When assessing the tasks performed by the student, at the same time the skills of the student are evaluated (and hence the preliminary courses taken by that particular student). It gives us information about insurmountable substantive gaps within the study curriculum.
- Students going abroad and students from abroad provide us with interesting information about their stay. During an individual conversation direct information on good practices is made available. Also comparison between both study programmes can be instructive.
- The student survey results are also discussed in focus group sessions with a selection of the students that participated in that survey. It gives the opportunity to deepen the survey

results and to focus on particular topics of the open questions. We are obtaining in that way interesting and more nuanced information on the strengths and weaknesses of the study programme. For the bachelor programme focus group, the selection of voluntary master students is straightforward. Combining the focus group for the master programme is more challenging, because the graduates have their focus on their newly acquired jobs. However, when doing this immediately, during the study period or immediately afterwards and on a regular basis, it incorporates the tradition of quality assurance and an attitude of problem solving, as is described in Leander Zaar and Andersson (2020).

There are some ideas in the pipeline, waiting to be implemented:

- Evaluation of a selection of master thesis by international peers, during or directly after the student assessment.
- Dedicated parts of quality assurance are evaluated by international partners from a research project or during/afterwards an international congress. For instance: structural alignment of one set of courses or a selection of learning outcomes can be discussed.
- A (online) meeting with international peers to evaluate the complete study programme, sharing best-practices and improvement opportunities.
- The organisation of a fair with posters where students present (preliminary) master thesis results. Not only relatives are invited, but also externals from the industry. Afterwards a (online) survey or a focus group meeting with the industry members can be organised to keep track of essential trends in the industry.
- Also students - as directly involved partners - can have valuable and meaningful comments when discussing structural alignment and/or learning outcomes.

LESSONS LEARNED

The whole process was very fruitful for all participants. The formation of the different working groups (with a mixture of colleagues and students) resulted in groups with a broad and sometimes challenging and critical view on the study programme. Colleagues learned each other in another way. The discussions in the working groups and in the entire study programme committee brightened understanding of the strengths and weaknesses of our study programme.

Because all courses are taught in Dutch, also the education monitor had to be written in the same language. This is now a challenging opportunity for obtaining critical views by externals, and especially for finding international peers. Also although window dressing (during the visit of an accreditation body) disappeared and a more realistic view on the study programme is given by the education monitor, the threat is now that it has a certain level of non-commitment and a lack of obligation.

CONCLUSIONS

The quality assurance of the electronics-ICT study programme at Ghent University is in this paper discussed. After a period of visits by the accreditation body, the portfolio system was very time-consuming and it was challenging to keep the evaluation of 55 processes and more than 100 indicators up-to-date. In the new system, installing a quality culture is performed at 4 levels (teacher, study programme, faculty and rectorate). This education monitor offers important information of the study programme's unique selling points and its strengths and weaknesses with regard to quality assurance. For 29 operational objectives there is self-evaluation using the PDCA-cycle, based on survey and other results originated from the intelligence business system. The use of Microsoft SharePoint as document management system resulted almost automatically in a quality improvement plan, including both programme-specific content and quality culture, meanwhile explicitly following the CDIO guidelines. The self-evaluation is combined with a critical view by stakeholders. Working together as a group of teachers and students, all in charge of the quality improvement, resulted in ameliorated dynamics and interaction and - as we believe - in a high quality in our electronics-ICT study programme.

FINANCIAL SUPPORT ACKNOWLEDGEMENTS

The author received no financial support for this work.

REFERENCES

Bennedsen, J., & Schrey-Niemenmaa, K. (2016). Using self-evaluations for collaborative quality enhancement - a case study. In *Proceedings of the 12th international CDIO conference* (p. 129-139). Turku, Finland.

Clark, R., Thomson, G., Kontio, E., Roslöf, J., & Steinby, P. (2016). Experiences on collaborative quality enhancement using cross-sparring between two universities. In *Proceedings of the 12th international CDIO conference* (p. 38-47). Turku, Finland.

Kontio, J. (2016). Enhancing quality together with CDIO community. In *Proceedings of the 12th international CDIO conference* (p. 154-163). Turku, Finland.

CDIO Standards 2.0. (2022). *available online at* `www.cdio.org`. accessed on: Jan., 14th, 2022.

Leander Zaar, F., & Andersson, M. (2020). Streamlining academic change processes through engineering principles. In *Proceedings of the 16th international CDIO conference* (p. 225-234). hosted on-line by Chalmers University of Technology, Gothenburg, Sweden.

McCartan, C. D., Hermon, J., Georgsson, F., Björklund, H., & Pettersson, J. (2016). A preliminary case study for collaborative quality enhancement. In *Proceedings of the 12th international CDIO conference* (p. 173-185). Turku, Finland.

Rouvrais, S., Audunsson, H., Saemundsdottir, I., Landrac, G., & Lassudrie, C. (2016). Pairwise collaborative quality enhancement: Experience of two engineering programmes in Iceland and France. In *Proceedings of the 12th international CDIO conference* (p. 186-195). Turku, Finland.

Shewhart, W. A., & Deming, W. E. (1939). *Statistical method from the viewpoint of quality control*. Washington: Department of Agriculture, Graduate School.

Verhaevert, J., & Van Torre, P. (2019). Teaching electronics-ICT: From focus and structure to practical realisations. In *Proceedings of the 15th international CDIO conference* (p. 120-132). Aarhus, Denmark.

BIOGRAPHICAL INFORMATION

Jo Verhaevert, PhD received the Engineering degree and doctoral degree in Electronic Engineering at the Katholieke Universiteit Leuven, Belgium, in 1999 and 2005, respectively. He currently teaches courses on telecommunication at the Faculty of Engineering and Architecture at Ghent University in Belgium, where he also performs research. His research interests include indoor wireless applications (such as Wireless Sensor Networks), indoor propagation mechanisms and smart antenna systems for wireless systems. He is currently also programme leader of the electronic engineering curriculum at Ghent University.

Corresponding author

Jo Verhaevert
Ghent University - imec
IDLab
Dept. of Information Technology (INTEC)
Technologiepark-Zwijnaarde 126
9052 Ghent
Belgium
jo.verhaevert@ugent.be