A QUALITY SYSTEM FOR ENGINEERING EDUCATION

Fredrik Georgsson

Department of Computing Science, Umeå Institute of Technology, Sweden

Ulf Holmgren

Department of Applied Physics and Electronics, Umeå Institute of Technology, Sweden

ABSTRACT

This paper describes a quality system for programme evaluation (standard 12) focusing on its roles and artefacts. The system has been in use for three years and has during this time been proven useful for systematically developing the ten different engineering programmes at our institute. The quality system has components both to ensure an increase in education quality and a quality assurance of the engineering education. One interesting feature of the system is that it has components that adjust the quality system itself, allowing it to evolve over time. It is claimed that the quality system shifts the focus of the quality discussion from an isolated course-oriented one to one focused on aligning course aims with programme aims. The cost of the quality system, expressed in full-time positions, is also discussed.

KEYWORDS

Programme evaluation, structured quality improvement

INTRODUCTION

At Umeå Institute of Technology we have developed a quality system setting the focus on our engineering programmes, four bachelors and six five-year masters, and during the fall of 2011 we completed the third cycle of the system. The system operates on a yearly basis and follows an observe-analyse-propose-fix cycle. In this paper a chronological description of a full cycle of the quality system is given, focusing on the formal roles and artefacts that constitute the system. There will also be a description of some support structures developed and there is a brief discussion on the cost of operating the quality system. Since the quality system is described chronologically it might be interesting to know that the academic year in Sweden is divided into two semesters: fall (September – January) and spring (January – June).

Table 1. A summary of the roles and artefacts comprising the quality system.

Artefact or role	Purpose of Responsibility
PD: Programme Director	Responsible for the quality work and the quality of the study programme.
PB: Programme Board	An advisory board to the PD. In the PB the different stakeholders of the study programme are represented: Students, Faculty and Industry. The board of the Institute appoints the PB.
PA: Programme Analysis	The main document in which the study programme is analysed from a number of different perspectives by the PD resulting in Quality Projects targeted at the identified weakness. The PB approves the PA before sending it to the board of the Institute.
QP: Quality Projects	Projects aimed at improving some quality aspects of the engineering programme. The project aims are identified in the PA.
QC: Quality Council	An advisory council to the board of the Institute with a special responsibility to proactively work with the quality of the study programmes. The quality system itself is a product of the QC. The QC annually revise the quality system and update the template for the PA.
PS: Programme Status	A one page quantitative summary of the PA agreed upon by the study board of directors and the PD.
CR: Course Report	A report that the responsible teacher makes official after a course is finished, reporting student appraisals on how well the course aims were taught and assessed.

THE QUALITY SYSTEM

Each study programme has a Program Director (PD) who is responsible for the quality work carried out within the programme. The main component of the framework that constitutes the quality system is the Programme Analysis (PA), which each programme (that is the PD) has to produce by October 15 every year.

The PA is a report, in which the programme

- states its aims and visions for programme development,
- describes the context in which the programme operates (departments, research groups, connections to industry etc.),
- presents a course matrix describing the connection between course aims and programme aims,
- describes other connections between courses (progression),
- analyses the flow of students through the programme,
- analyses student retention and the recruitment situation,
- establishes how well the programme meets the twelve CDIO-standards,
- most importantly identifies the main weaknesses of the programme that should be addressed the upcoming year,
- and finally evaluates the improvements carried out as a result of the previous year's PA.

Before submission, the PA must be presented to the Programme Board (PB). The PB is an advisory board constituted by the stakeholders of the programme: Faculty, Students and Industry.

By October 30 the programme should present Quality Projects that target the identified weaknesses. An application for funding could be submitted to the board of the institute by the same date. The funding is primarily intended for financing person-hours within the project.

In November the board of the Institute decides on which projects to fund so that the QP given funding can start in January. The board may decide on joint projects involving several programmes if the project aims are similar. QP not requiring extra funding from the Institute can start when the programme decides it necessary.

In January-February each programme represented by the PD is given oral feedback on its PA by the Directors of Study and the Chairman of the Institute of Technology. At the same time a one-page summary of the Programme Status (PS) is agreed upon. The PS describes and quantifies

- the track record of the programme (employability of its alumni, prizes and awards, ranking of the programme made by external organisations etc.)
- the strategic importance of the programme for the university, department, industry, region, nation, etc.
- the current status of the programme, that is how well does the programme meet the twelve CDIO standards and some extra criteria involving staffing and research connections.

The purpose of the PS is partly to serve as basis for strategic discussions in the board of the Institute and partly to show that the programme and the board of the Institute have the same understanding of the qualities and shortcomings of the programme.

Support structures to the Programme Director

The formal support structure given to the PD is the Programme Board. Typically the PB meet three times per year to advice the PA in the running of the programme. Besides from the PB, which is appointed by the Institute of Technology, it is up to the PD to arrange additional support structures in the running of the programme. These arrangements are done differently by different PDs.

One example of complementary support structures is within the IT-area where the PD has the following support structures in addition to the PB:

- An industry network that meets three times per year. In the network there are about fifteen different companies, and about ten appears regularly at meetings. Out of the fifteen representatives there are several alumni from the programme. The purpose of these meetings are a) to discuss guest lectures and industry involvements in courses, b) to follow up on previous industrial involvement and c) to discuss the overall qualities of the programme from the industrial stakeholders' point of view.
- At the start of each semester the PD meets with the students of each year of the programme. The purpose of these meetings is to a) introduce the upcoming semester, what courses the students are about to take, b) explain how the courses contribute to the competences and skills needed to work as an engineer and c) to follow up the previous semester.
- Before the start of each semester the PD meets with the teachers responsible for the courses a specific year of the programme is going to attend that semester. The purpose of these meetings are to make sure the teacher understand a) the role of the course in the programme, b) what courses the students have taken before this particular course, c) why they need this particular course in their coming studies and d) to suggest guest lectures from the industry. Since many of the coursers are taken in parallel with other courses this is also an opportunity to synchronise the workload between courses.

The semester meetings with teachers and students mentioned above are actually a result of a QP aiming at increasing the understanding of the programme aims amongst staff and students. The semester meetings are very appreciated by teachers and students. Based on a survey given to the students of year 1-3 of the programme, we conclude that 100% claim that they know why they take different courses and 85% claim to have a clear picture of what their studies will amount to (in a professional sense). Since only 88% of the students claim that it is important for them to know what their studies will amount to we are pleased with the result.

Another informal structure that also is a result of a quality project is an engineering network for the PD of the engineering programmes. This network meets a couple of times per semester to discuss current issues that the engineering programmes have in common. In addition to these meetings the network arranges shorter (1/2 day) and longer (lunch to lunch at some conference venue) workshops with purposes to allow for lengthy discussions of certain topics. In June 2012 there will be/was a workshop on Lean with a follow-up longer workshop in August.

There is also a Quality Council (QC), which is associated to the board of the Institute of Technology with a responsibility of systematically addressing quality issues of the programmes administered by the Institute. It is in fact the QC that has developed the entire quality system. The QC is a support structure to the PD since it aids the programmes by developing administrative tools for data extraction from central databases, course evaluation etc. to be used in the preparation for the PA. The aim is to allow the PD to focus on analysing the data and not spending time on collecting it and the goal is to have fully automatic data extraction.

One example of such a support tool is the Course Report (CR) in which the course responsible teacher summarises the course with a focus on how well the course that is actually given meets the course specified in the course syllabus. The teacher has to show statistics of to what extents the students think that each of the course aims are being taught and assessed. The CR provides feedback required for the PD to know that each course meets its intended role in the programme as designed. The CR is also used as a basis for the semester follow-up discussions with the students as described previously.

The template of the PA is decided by the QC and during the spring the QC analyses all the PAs in order to see if some crucial points are systematically missed in the analysis, if different data should be extracted etc. Based on this analysis the QC decides on changes of the template of the PA. This update of the template is in all essence a quality adjustment of the quality system making the quality system improve slightly for every year.

The QC also arranges seminars in order to educate PDs and others in the quality system and the support tools developed.

RESULTS

The quality system has been applied for three complete cycles and the system described in this paper is the current version. As stated in the paper, the quality system itself adapts continuously making it difficult to find quantitative measures that have persisted over the three cycles. For instance, the explicit demand on assessing the 12 CDIO standards was added in the last cycle, even though some programmes has provided the information in all three cycles.

One example of this longitudinal data is given in Figure 1 below where data for the five year Masters of Engineering programme in Computing Science is given. Each standard is estimated on a five-graded scale, where a 5 is given if it is estimated that the programme has a real CDIO-identity with regards to the standard and a 1 is given if the programme has not addressed the standard at all. For more on the CDIO-standards, please refer to [1].

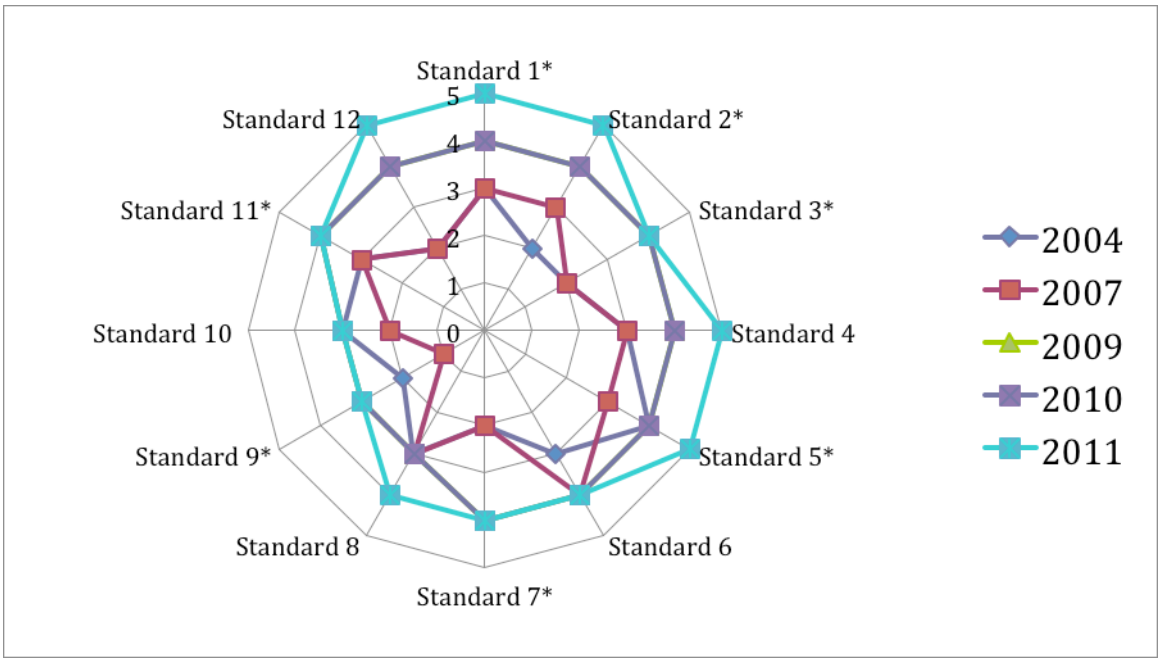

Figure 1. An example of how the five-year Masters of Engineering programme in Computing Science has developed over time when it comes to meeting the 12 CDIO standards.

In Figure 2 statistics for 2011 collected from the PA for all engineering programmes at the institute are presented.

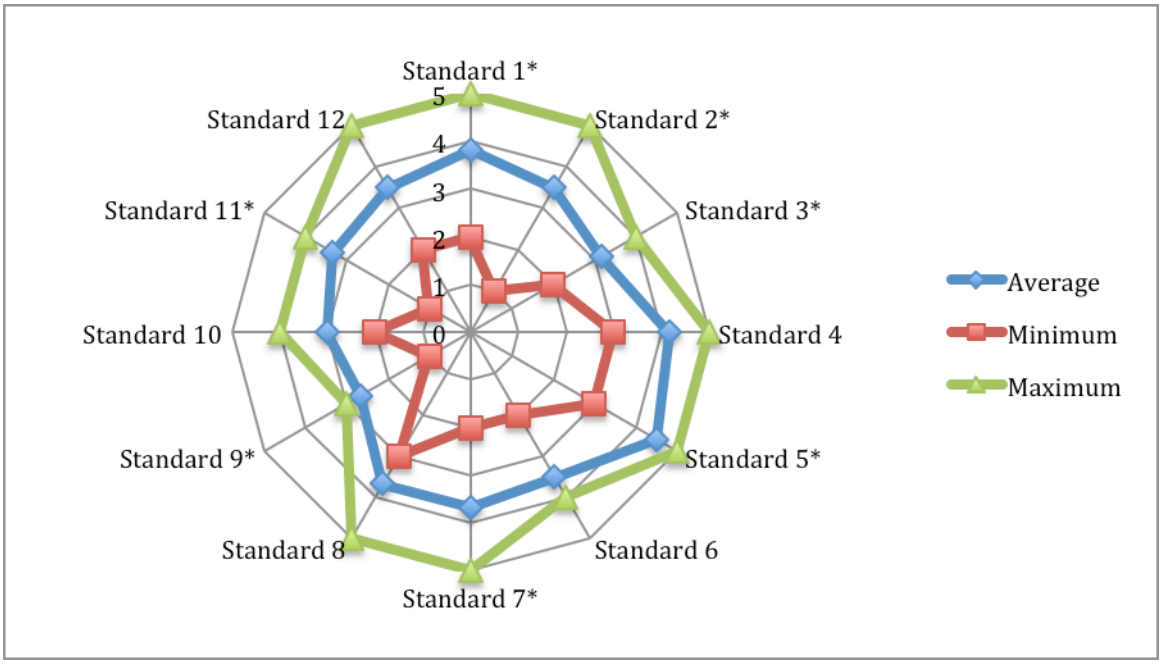

Figure 2. The self assessed fulfilment of the 12 CDIO standards as found in the PA for all the engineering programmes at the Institute. For each standard the minimum score, average score and maximum score is given.

Associated Cost

For the quality work each five-year programme has a time resource equivalent of 12.5 percent full-time position, a three-year programme has 7.5 percent. This time resource is normally given to the PD on top of his/her ordinary twenty/fifteen percent of full-time position allotted for being a PD. The total cost of operating the quality system is thus equivalent of 1.4 full-time positions for the ten programmes involved, including quality time to PD, representation in the QC and the time to provide feedback from the Directors of Study.

DISCUSSION

There certainly are several positive examples of quality improvements as a result of quality projects initiated within the quality system; examples of some are given in the text above and in Table 2. Nevertheless we claim that the main contribution of the quality system is not the actual quality projects but the fact that each programme on a regular basis assesses where it is and where it ought to be from a quality point of view. This introspective analysis increases the awareness of issues affecting the quality of the engineering programmes, making it easier to ask the right questions and address the right issues when working with programme quality. This can be observed in the fact that assessment of the 12 CDIO standards tends to be rather high the first time it is done within a study programme, but as the PD gains insight on the complexity of the standards and the actual status of the programme more, realistic assessment are achieved.

In Table 2, some examples of joint projects are seen: The education of teaching staff in project management and the development of criteria for assessing thesis work to mention a few. In both these projects all BSc in Engineering programmes work together. Another example of such joint project is the development of criteria for project courses where all MSc in Engineering programmes worked together with industrial stakeholders in the project.

The budget for project funding was for 2011 about SEK 300´ (roughly $30 000 USD), but as can be seen in Table 2 not all available funding was handed out that year. It is a clear trend that the number of QP put forward for external funding is decreasing. In 2009 there were 22, in 2010 there were 16 and in 2011 there were only 4. In fact, many of the 2009 and 2010 projects have been difficult to staff and have been postponed and have not started until 2010 or 2011. There are indeed projects that have been aborted although they have received funding. The reason why we have had this development is the fact that in 2009 and 2010 the PD did not have to have an approval of the staffing plan of the project from the head of the department for applying for funding. The problem is that the PD has no authority to staff projects with any other than him/herself and then only with time allotted for PD or quality work. That is, it does not matter if the project receives external funding or not since the head of department do not have to allow any of his/her staff to participate in the project. In 2011 the PD had to have the staffing plan of the project approved by the head of department in order to apply for funding for a QP. Hence the drastic decrease in the number of QP.

Some projects that are not justified well enough by the PA are not granted funding and there have been at least 3-4 projects per cycle that has not been granted external funding. The study programme has funded and staffed some of these internally and some of these projects have not been carried out at all.

From Figure 2 it is clear that the standard that achieves the lowest average score is standard 9 (the CDIO-competence of teaching staff). This is easily explained by the fact that the university has a strong tradition of education within natural science and about 80-90% of the teachers are scientists and not engineers. There are some projects that have been initiated to address this with the aim of increasing the awareness of what the role of an engineer is. It

is also clear from Figure 2 that standards 4 (introductory course) and 5 (DBT-course) achieve the highest score. This is explained by the fact that the first projects initiated when starting the quality system concerned these standards.

From Figure 2 is also clear that for some standards there is a considerable span between the lowest and highest score. Most noticeable is standard 2 (learning outcomes) where the lowest score is 1 and the highest is 5 (average score 3.5). The engineering programme claiming the low score on the standard is the five-year MSc programme in Engineering Physics. This particular engineering programme is very broad, spanning over many departments and the courses that the students attend are shared between many programmes, both engineering and science programmes. This makes it difficult to optimise the learning outcomes of the courses. It is a known problem and has been addressed by several QP.

It is of course viable to ask if the results of the system motivate the relatively high cost of maintaining the system. The QC can clearly see that the quality of the PA increases with each cycle, as there are more insightful reflections in the current versions of the PA than in the first ones. The extra amount of time allotted to the PD for writing the PA is only given during a start-up phase and is decided upon on a yearly basis. When the start-up phase is over, the PD will have to produce the PA as a part of the normal duties as a PD. By then the QC will have fine-tuned the system and developed support structures as well as raised the general awareness of the importance of a continuous quality work to motivate the continuous usage of the system.

During 2012 all engineering programmes in Sweden will be subjects to a review from the National Agency for Higher Education. When preparing for this work, QC has seen that it is very clear that if we had not been writing the PA for the last three years we would be much less prepared for what to come.

CONCLUSION

By using our quality system we have been able to shift the focus of the quality work within the engineering education at our Institute of Technology. Previously, when people spoke about quality in the engineering programmes it was a very course centric discussion, focusing more or less on how courses were taught and the amount of research connections possible to cram into a course. These are of course very important issues to keep in mind, but it turned out that there were some more relevant issues to address. Examples of such issues were developing common definitions of project courses, educating teaching staff in project management, aligning course aims and making sure that the courses fulfil their roles in the study programmes, to name just a few.

One problem of the quality system is the fact that the PD has no authority to staff projects; this privilege lies with the head of department. If there is a general shortage of staff the head of department might decide that staff is needed for other tasks and the quality work of the programme is crippled. In the organisation we reside there is no simple solution to this problem.

During the start-up phase it is difficult to estimate if the cost benefit ratio motivates the use and current complexity of the quality system. There has undoubtedly been an increase in the quality of our engineering education but it is extremely difficult to say if better results would have been reached by spending the resources differently, but on the whole, we believe not.

Table 2. Examples of QP funded by the board of the Institute initiated within the quality system during the last three cycles.

Year	Project	Programme	Granted
2011	Improving alumni activity	Mechanical, BSc	SEK 20’
2011	Marketing the programme	Mechanical, BSc	SEK 21’
2011	Developing a project course in embedded systems	Computing, MSc	SEK 100’
2011	Developing a support system for handling student thesis work	Computing, MSc	SEK 20’
2010	Developing a course in molecular spectroscopy	Eng. Phys, MSc	SEK 65’
2010	Developing a course in algorithmic problem solving	Computing, MSc	SEK 50‘
2010	Developing a net-based course	Eng. Phys. MSc	SEK 45’
2010	Educating teaching staff in project management	All BSc programme	SEK 70’
2010	Developing assessment criteria for assessing thesis work. Part II: Increasing teaching competence	All BSc programme	SEK 100’
2010	Developing a course in engineering didactics	All engineering programmes	SEK 100’
2010	Alumni follow-up	Energy BSc	SEK 34’
2010	Developing course in wind power technology	Energy BSc	SEK 15’
2010	Developing course in Energy technology	Energy MSc	SEK 40’
2010	Alumni follow up	Energy MSc	SEK 41’
2010	Portfolios, follow up project	Computing, MSc	SEK 10’
2010	External view of the programme	Computing, MSc	SEK 17’
2010	Increasing the team sprit amongst the students	Computing, MSC	SEK 8’
2010	Profiles	Eng. Phys. MSc	SEK 89’
2010	IT and Design 10 years	IT and Design, MSc	SEK 20’
2010	Applied Course	IT and Design, MSc	SEK 40’
2009	Criteria for assessing and evaluating project courses	All MSc programme	SEK 140’
2009	Teaching material on how to write and present reports	All engineering programme	SEK 118’
2009	Developing the civil engineering programme	Civil Engineering BSc	SEK 40’
2009	Portfolio for mechanical engineering	Mechanical BSc	SEK 60’
2009	Identifying stakeholders for computer engineering	Computer BSc	SEK 25’
2009	Follow up on students admitted 2002-2006	Computer BSc	SEK 25’
2009	Developing assessment criteria for assessing thesis work. Part I	All BSc programme	SEK 60’
2009	Developing labs in biotechnology	Biotechnology MSc	SEK 88’
2009	Follow up on students in IT and design	IT and design MSc	SEK 25’
2009	Tools for visualising the aims of the programme	IT and design MSc	SEK 20’
2009	Handling distance course in regular	IT and design MSc	SEK 20’

	campus based education		
2009	Tools for interfacing student administrative databases	All Engineering programmes	SEK 50’
2009	Alumni event	Computing, MSc	SEK 20’
2009	Introducing mentors, a pre-study	Computing, MSc	SEK 10’
2009	Follow up on students in Computing Science	Computing, MSc	SEK 19’
2009	Increasing the level of entrepreneurship	Computing, MSc	SEK 10’
2009	Introducing semester introductions for teachers and students	Computing, MSc	SEK 10’
2009	Alumni mentors for female students	Eng. Phys., MSc	SEK 28’
2009	Continuous contact with industry	Eng. Phys., MSc	SEK 43’
2009	Increasing the programme spirit amongst teachers	Eng. Phys., MSc	SEK 10’
2009	Template for the Programme Analyses	All Engineering programme	SEK 42’
2009	Analysing Programme Analyses	All Engineering programme	Funded by QC

REFERENCES

[1] *CDIO Standards*. Retrieved April 23, 2012 from CDIO: http://www.cdio.org/participate/communication-forum/cdio-standards-v-20-customized-rubrics

Biographical Information

Fredrik Georgsson is a senior lecturer at the Department of Computing Science at Umeå University. He is the program director of the five years master’s program in Computing Science and Engineering and a member of the Quality Council of the Faculty of Science and Technology of Umeå University. In addition to this he also works with increasing the industrial involvement in all engineering programmes at the Umeå Institute of Technology.

Ulf Holmgren is a senior lecturer at the Department of Applied Physics and Electronics at Umeå University. He is a programme director of the three years bachelor’s programme in Electronics and Computer Engineering and a member of the Quality Council of the Faculty of Science and Technology of Umeå University.

Corresponding author

Dr. Fredrik Georgsson
Department of Computing Science
Umeå University
SE-901 87 UMEÅ, Sweden
+46 70 242 1099
fredrikg@cs.umu.se