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Subject-Level Quality Assurance In Computing

Experiences From Three National Perspectives

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***Abstract*—This paper examines some aspects of the Quality Assurance processes in Computing departments in three European universities. We first examine the operation of a quality assurance activity in the School of Computer Science in Iceland. The next case is an example from Sweden and finally we present a case from the United Kingdom. In each case, we examine the motivation for the outcome-based assurance methodologies that predominate in countries that are engaged in the Bologna Process in terms of the use of competence-based assessment. We compare the application of these processes to departmental review, focusing on the aims and objectives, who controls the process, the areas covered, the methodology and the use to which the information is put. We discuss some of the implications for teaching when different quality assurance processes are used and finally, we make some observations about the relatively sparse literature on Computing Education subject-specific quality assurance.**

Keywords—outcome-based quality assurance; qualifications frameworks; learning outcomes; competence-based assessment;

I. INTRODUCTION

Higher education has undergone significant change over the past forty years with changes in education policy leading to a substantial expansion in the number of students entering the university system. In many countries, the number and type of tertiary education institutions has increased, often with greater public scrutiny of funding, accompanied by a more prominent role for the private sector. Such developments have resulted in significant changes to the nature of the service that universities provide and this, in turn, has led to a transformation of expectations about the role these institutions play in society. At the present time, the challenges of globalization, the increasingly widespread movement of students across national borders, and the emergence of transnational educational markets (as evidenced by international university rankings) continue to transform the structure and function of universities, with changes appearing to proceed at an accelerated pace [1].

While these changes have had a profound effect at an institutional level, they have also had a significant impact on educational practice at the departmental or subject level. This has been especially noticeable in traditional engineering subjects where a global employment market and high levels of graduate mobility has meant that issues of quality assurance have become increasingly important, leading to considerable research into the objectives, procedures and outcomes of the quality assurance process [2]. Computer Science also produces graduates for a global employment market, and there has been an increasing awareness of the need to incorporate global perspectives into university teaching. This has been reflected in the development of international models of curricula and teaching practice [3], as well as increased attention to the development of professional skills related to international practice, e.g. intercultural competence, which are deemed to promote employability in this area [4]. However, while the emergence of this pedagogical strand is undoubtedly important, it has not so far led to the same degree of comparative analysis and review of the specific practices of subject-based quality assurance in Computing that has occurred in other Engineering contexts.

The structure of the paper is as follows: we begin to attempt to give such an analysis of the quality assurance processes in the discipline of Computing. We start by discussing some of the key ideas that underlie the quality assurance processes found in the European context. Following Woollacott [5] we discuss the concept of quality in the context of the kinds of stakeholders found in higher education and look at the notion of competency and the way that it gives rise to process-centred and outcome-centred approaches to quality assurance. We take as our academic context, Computing departments of universities located in three European countries - Iceland, Sweden and the United Kingdom (Scotland). These cases share some similarities in their particular educational context but also have some notable differences. Sweden and the UK are members of the European Union, whereas Iceland is not, although it is a member of the European Free Trade Association, and so closely affected by what occurs within the E.U. Nevertheless, all three countries are part of the European Economic Area and are engaged in the Bologna Process aimed at ensuring comparability between higher education qualifications through adoption of the Qualifications Framework for the European Higher Educational Area. We believe that it is instructive to give these examples as some illustration of the variety of response to the challenge of subject-specific quality assurance (in Computing). We describe the motivating factors that inform the national quality assurance frameworks and examine how these factors affect the methodology that is adopted, and the interaction of the various stakeholders with the process itself. We compare the

application of these processes to departmental review, focusing on the aims and objectives, who controls the process, the areas covered, the methodology and the use to which the information is put. Finally, we make some observations on the differences between the national approaches to quality assurance and the implications for teaching and learning in a globalized educational environment.

II. BACKGROUND

As remarked by Woollacott [5], quality is a complex trait that requires a sophisticated understanding, not just of how well a particular product or service fits its proposed context, but also how those who use that service react to it. When defining quality, and implicitly when discussing issues of quality assurance, it is important therefore to identify the expectations of stakeholders with respect to what is being judged, as a vital component in examining performance. In a commercial context, it may be possible to make the claim that the customer, or contractor for the service or product, is the primary stakeholder, but when we move into the area of higher education, the identification of a single customer appears to be problematic. Certainly, the simple assignment of the customer role to the student is not straightforward [6]. If there are multiple stakeholders who each have a claim to have an interest in the success of the sector, then a more useful way of approaching this problem may be to consider the concept of "curriculum responsiveness". This is the degree to which the educational programme set out by a university, both taken as a whole and as exemplified in subject-specific domains, should be able to engage with the legitimate concerns and interests of students, academics, employers, government agencies, and the wider society [7].

In his discussion of quality education in engineering disciplines, Woollacott identified four kinds of curriculum responsiveness associated with four principal stakeholders. The first is economic responsiveness which deals with how the curriculum reacts to the demands for highly qualified workers who can engage in the tasks necessary for the smooth running of modern globalized economies. The second is disciplinary responsiveness, which is a function of how well the curriculum can adapt itself to ensure that students receive an education that is informed by the best scholarship and academic and professional practice. A third type of responsiveness is cultural or societal in nature and depends upon how easily the educational system can incorporate the cultural diversity of students, while the fourth is learner responsiveness which reflects how the curriculum can accommodate the individual learning needs of students. The stakeholders in the first, second and third cases are the workforce, the discipline, and society as a whole. Only in the fourth case is the student the primary stakeholder and consequently only if we ignore the wider socioeconomic and academic consideration of higher education do we arrive at a concept of "student as customer". Instead, by allowing for multiple groups with a range of views, we find that the optimal situation would be that the sector should attempt to satisfy the expectations of as many stakeholders as possible.

When trying to assess the quality of a product or service, it is natural to focus on the question of what makes it fit for purpose. In terms of higher education, this is related to issues of curriculum and hence to its responsiveness to the variety of stakeholder expectations. Nevertheless, there is still the question of what exactly we measure in order to arrive at an assessment of the quality of educational provision. If one of the outcomes of higher education is, say, that we should produce a skilled workforce, then we need to know what it is that differentiates a skilled worker from an unskilled one. Similarly, if an objective to produce graduates with a range of cognitive skills that will allow them to function well in a changing learning environment, we need to know how to assess whether efforts to accomplish this have been successful.

This is usually done by trying to relate proficiency in some competency that a learner should acquire or develop to the measurement of some aspect of performance of a task that would rely on that competency. The difficulty is that competencies are internal attributes that can only be assessed by measuring some indicator or proxy during the completion of some task. The nature of this performance, and hence the indicator for competence that is measured, has certain inherent ambiguities. If one thinks of performance in terms of output, then the assessment is made by examining the quality of deliverables produced in the task. This type of outcomes-based assessment is one methodology that is used to derive measures of quality. Alternatively, one can think of performance in terms of the activities that underlie the output and focus on the behaviours and processes required for successful completion of the task. This would lead to a process-based quality assurance methodology.

Recent developments in higher education quality assurance have tended to promote an outcomes-based approach that focuses on the demonstrable products of the educational experience as expressed in learning outcomes. As pointed out by Ewell [8], this is partly due to the demands from public funding bodies that universities adopt a "culture of evidence," characterized by the continuous collection and use of evidence about student learning to improve teaching and the general educational experience. Nevertheless, the use of outcomes-based assurance methods can be justified on a number of sound pedagogical considerations. The requirement that course objectives and performance indicators be articulated in terms of the learnt competencies of the students themselves is much closer to the constructivist paradigm and its implementation in models of student-centred learning supported through such mechanisms as constructive alignment [9, 10].

At the level of the individual student, such learning outcomes are expressions of what learners are expected to achieve and how they are expected to demonstrate this. They necessarily focus on the student's competence rather than the process through which instruction is conveyed. However, at the program level, such outcomes are often more broadly defined in terms of the cognitive development of the individual students, and articulating outcomes associated with this can be difficult unless some attention is also given to the processes by which the development occurs.

This outcomes-based approach has been adopted generally in many countries as a result of the Bologna Process [11]

which seeks to develop a common model for higher education throughout Europe. In order to devise a common framework which would allow explicit comparison to be made between elements of different national higher educational systems, the aim was that all programs should be based on learning outcomes and that, where necessary, curricula should be redesigned to accommodate this task. This has resulted in the development of national qualifications frameworks [12] in many European countries, (e.g. the Framework for higher education qualifications in England, Wales and Northern Ireland, the Scottish Credit and Qualifications Framework, the Icelandic Qualifications Framework, etc.) in which degrees are mainly described in terms of competence-based learning outcomes.

III. Quality Assurance in Iceland

Iceland has eight institutions of higher education (*háskóli*), the role of which is defined by legislation that applies to all institutions providing education that leads to a degree or other qualifications at tertiary level. In Iceland, the term higher education applies to all education at tertiary level, including traditional universities that carry out teaching and research, as well as to specialized higher education institutions and to tertiary education colleges without research obligations.

Quality assurance among these institutions is ultimately the responsibility of the Ministry of Education, Science and Culture and they exercise control of a regulatory system that has both supervisory and enhancement elements. In 2010, the Ministry established an international Quality Board and consultative Quality Council for Higher Education. The Quality Board is the independent agency responsible for organising and carrying out all external quality assurance in higher education. The Quality Council is an advisory board for the Quality Board. All institutions that wish to operate in Iceland are obliged to undergo accreditation.

A. *Quality Assurance at Reykjavik University School of Computer Science*

The bachelor program in computer science at Reykjavik University, which began in 1998, was strongly influenced by the 1991 ACM/IEEE computer science curricula [13]. In 2013, it was the subject for a quality assurance review as part of the national quality assurance review cycle, following publication in 2011 of the Quality Enhancement Framework for higher education in Iceland [14]. The prime objective of the framework is to support higher education institutions in evaluating the quality both at an institutional level and at the subject level for each department or school in the institution. As specified in the Quality Enhancement Handbook for Icelandic Higher Education [14] "all institutions will be required to conduct regular internal reviews covering each of their subject areas". The School of Computer Science at Reykjavik University was asked to conduct its internal review, termed "subject-level review" (SLR), during the 2013 calendar year.

There were initial discussions on how to conduct the quality assurance process for the computer science program and experiences from the recent (2012-2013) national quality assurance process for computer science programs in Sweden were brought up. The heavily outcome-based Swedish process served as a motivation to investigate how the Icelandic national degree criteria [15] could be used. The national degree criteria were found to be natural and important as ultimate goals to measure against, but also too abstract to be used directly in a quality assessment of the computer science program. As a consequence, it was decided to use the ACM/IEEE Computer Science Curricula 2013 (Ironman draft) [16] (referred to as the ACM curricula in the following) as a bridging document since it contains connections to the broad and abstract goals of computer science programs as well as concrete definitions about computer science content.

The connection between the national degree criteria and the ACM curricula is mostly taken from chapter three, *Characteristics of Graduates*, in the ACM document. This chapter provides material to anchor the national degree criteria in the computer science discipline. For example, the criteria that a student graduating from a bachelor of science program should be "capable of interpreting and presenting scientific issues and research findings", [15] has a close correspondence with the ACM curriculum guidelines:

"*Communication and organizational skills: Graduates should have the ability to make effective presentations to a range of audiences about technical problems and their solutions. This may involve face-to-face, written, or electronic communication. They should be prepared to work effectively as members of teams. Graduates should be able to manage their own learning and development, including managing time, priorities, and progress*." [16, p.22].

The latter also provides more information about how to interpret the degree criteria.

The ACM Curricula can therefore be used to provide a fine-grain definition of the topical areas of computer science, and, importantly, the definition of the computer science body of knowledge in chapter four can form the basis for assessing the match between the computer science program and the central areas of the ACM curricula. The ACM document can therefore also be used to provide a clarification of how the abstract national degree criteria can be translated into concrete learning objectives in courses in the computer science program.

The chosen evaluation process for evaluating the curricula in computer science at Reykjavik University can be seen as being composed of two parts. The first is process-oriented and looks at how the program is set up and conducted. Compulsory courses were evaluated against the core topics and learning outcomes in the body of knowledge from the ACM curricula 2013 [16]. The other part is outcome-oriented, based on learning objectives, as described in the characteristics of graduates [16]. This is evaluated using data from a questionnaire and interviews with major companies concerning the performance of graduates from the program. In addition, all faculty members teaching mandatory courses

were asked to rate to what extent they emphasise in their courses the subjects described in the characteristics of graduates.

IV. Quality Assurance in Sweden

Quality assurance processes in Sweden are based on the current national quality assurance evaluation run by the Council of Higher Education (from 2013 Universitetskanslersämbetet - The Swedish Higher Education Authority) [17]. All bachelor and master degrees in all subjects, as well as special degrees, such as engineering, is evaluated in the 2011-2014 period..

The evaluation is outcome based intended to measure how well graduates meet the national learning objectives for the different degrees. These learning outcomes fall in three categories; 1) Knowledge and understanding, 2) Competence and skills, and 3) Judgement and approach. A set of these learning outcomes is chosen to be evaluated against and each degree is assessed by a panel on a three-level scale; Very high quality, High quality, and Inadequate quality. The panel consist of subject experts, students, and representatives from the labour market. Programs that are deemed to be of inadequate quality are reviewed a year later in order to decide if the entitlement to grant a degree should be revoked or not.

The evaluation is based on students' independent projects (degree projects/theses), institutions' self evaluation, interviews with institutions and students, and alumni questionnaires. The independent project reports and the self evaluations are evaluated by the members of the evaluation panel based on the selected learning goals. Members of the panel later conduct interviews with students and with faulty in order to complement the impression. The alumni questionnaire is used similarly if enough alumni have answered the questionnaire. The independent project reports is the main source for the evaluation, which means that it is not possible to change the evaluations of those learning goals that can be evaluated based on the independent project reports.

A. The computing and IT area evaluation

Computing and IT was evaluated in 2012-2013 together with other engineering degrees. The evaluation panel consisted of 22 persons, 17 subject experts (14 from Sweden, two from Norway, and one from Finland), three students, and two representatives from the labour market. There were also roughly twenty expert readers called in to help out with the evaluation of the over 900 independent project reports. The number of independent project reports chosen were determined by an algorithm based on the number of reports passed during the previous two years. For small programs this meant that all the reports were chosen, but for most a random selection was made. This meant that each person graded a little bit over 20 reports since each report was only assessed by one person.

The panel met a few times to discuss the chosen learning goals and especially how to grade them. The discussion involved coming to agreement what was meant with the different learning goals and also how they could be evaluated based on independent project reports. It was obvious that this was needed and not surprising since wordings for learning goals at the bachelor and master levels were quite similar and that most were unfamiliar with assessing in the areas of competence, skills, judgement, and approach. The expert readers met for less than half a day to get coordinated in their evaluations.

1) Independent Project Reports

The main source for evaluation was independent project reports based on the assumption that this was where a graduate is supposed to show the breadth and depth of what he/she had learned. The chosen reports were made anonymous before being sent out. The evaluation was not to take into account if there were more than one student writing the report, nor any other contextual information, e.g. if the report was made at an academic department or in industry. There were some learning outcomes, e.g. ability to present orally, that clearly were not relevant for assessment through a report and an evaluator could then use the grade "not relevant". The recommendation was that this grade should be used sparingly

2) Self Evaluation

Most institutions made quite an effort to produce their self evaluations, one for each degree offered at the institute. The format was restricted in size and there was a suggested structure to follow. Some degrees were allowed 20 pages and others 30 pages. These self evaluations presented the setting for the degree and provided, or tried to provide, evidence that all the selected learning goals (degree criteria) were met. Each self evaluation was read by fours persons, two subject experts, one student and one representative from the labour market.

3) Interview with Students

These were conducted by the persons reading the self evaluation from the institute in question together with a civil servant from the Council of Higher Education. The student groups were supposed to consist of students from each degree offered. The interviews were made over the net using the Adobe Connect web conferencing system and lasted for about one and a half hour.

4) Interview with Faculty

The interviews with faculty at the degree granting institutions were conducted by the same persons that did the interview with the students and using the same technique (Adobe Connect). The faculty group typically consisted of coordinators for each degree offered and a set of other persons supposed to be experts at the questions the institutions expected. The evaluation group had sent out some information regarding what they were interested in knowing more about and the meetings lasted for about two hours.

5) Alumni Survey

A set of graduates from the last two years was selected and a questionnaire was sent to them. The questions were tailored to the selected learning goals. Results from this survey were only used if at least 50% had answered out of the twenty that were selected. Most of the degrees did not reach this threshold.

6) Judging Degrees

Each degree offered at an institution got a grade on the three-level scale presented above. The grading rubric was such

that if one of the chosen learning outcomes came out as being unsatisfactory, then the whole degree was judged as unsatisfactory. A majority of the selected degree criteria had to be on the highest level for the degree to be judged as being of very high quality. There were between five and seven learning outcomes chosen for each degree, e.g. five for the bachelor degree. Each learning outcome was divided into a few sub-learning outcome.

Judging a learning outcome, or sub-learning outcome, was mainly based on evaluating the selected reports. Additional information, such as the self evaluation or the interviews, could be used if the criteria could not be judged by the reports, like for the ability to present orally sub-learning outcome. Borderline decisions could also be determined based on other sources than the reports. That is, no additional evidence could be used to grade a learning outcome if the evaluation of the report showed a clear result.

7) Impressions From Being an Evaluator

To be a member of the evaluation group was interesting and frustrating. It was interesting to discuss what it meant to evaluate against the selected learning goals, especially the less technical ones. The outcome was also quite interesting to discuss.

The strict regulations regarding how to make judgment was often quite frustrating. The main concern was regarding the little freedom to go against the "results" indicated by the independent project report. There were degrees with only five reports evaluated, and since there was a substantial difference between the persons grading (some had an average of 1,5 on a three point scale and some 2,5) it was regarded that "luck" could play a too large part in the result. Another reason was the varying conditions under which the reports were written. Some were the result of groups of up to six students producing the thesis in course like setting, whereas others were done in the industry were the students had their first employment. A further source of frustration was the low level of information on the grading, especially since most graders gave a grade even where it could be assumed that there were very little evidence for a grade in the report and only provided very little, if any, information regarding the verdict.

8) Outcome of the Evaluation

There are a few rather interesting general observations regarding how institutions came out of the evaluation. Most of the large institutions did rather poorly, with only a few degrees passing. This seemed to the evaluation panel not adequately reflect the quality of the graduates from those institutions, but rather as a result of a strict evaluation process coupled with a non-robust evaluation process of independent project reports. Some small institutions did quite well, whereas others came out quite bad. The general impression is that some of the small ones that failed also had rather shaky degree programs.

The impression is that the less technical learning goals were given some slack in the evaluation in that they were not put in question to the same degree as the more traditional subject related learning goals. Some evaluators expressed that they were surprised that the results from the reports corresponded well with their general impression of the degrees examined. This was however not a general view.

9) Sweden Excluded from ENQA

The European association for quality assurance in higher education (ENQA) was founded as a network (hence the "N" in the acronym) in 2000 by the European Union and was transformed to an association in 2004. Sweden was one of the founding members. ENQA launched an investigation of the quality assurance process in Sweden and came up with several objections and Sweden, or rather The Swedish Higher Education Authority, is now excluded after a period of being a "Full member agency under review". The critique concerned a lack of independence in that the process was seen to be under the controlled of the government to a too high degree. Another issue was the lack of connection to internal quality work and especially lack of feedback regarding how to improve the education. The latter is a result of the focus on learning outcomes and decisions being motivated by comments on the observed results. Other comments were that it was the quality of the students that were investigated and not the education as such. There are also concerns about the quality of the process and thus potentially coming up with unreliable results.

The Swedish government has recently launched an investigation regarding how quality assurance should be done in the future. The instructions state the following:

- The system should coordinate efforts made by institutions and the Swedish Higher Education Authority.
- The system should control that the students obtain the stated learning goals.
- The system should drive quality work and provide institutions with incentives and guidance regarding development of their educations.
- The usefulness of the education should be an important aspect of evaluations, especially with regard to the labour market.
- Students should have a clear role in the system.
- European level principles should be taken into account.
- Revoking entitlement to grant degrees should continue to be part of the quality assurance system.
- The system should take local profiling into account and be transparent and clear.

V. Quality Assurance in UK

Quality assurance processes in Higher Education in the United Kingdom is overseen by the UK Quality Assurance Agency (QAA). This is an independent body charged with safeguarding academic standards and improving the quality of UK higher education. It does this by supporting higher education providers in meeting their responsibilities for academic standards and quality by ensuring that the institutions conduct periodic reviews of practice. It publishes guidance to help develop effective systems, the primary source of this guidance being the "Quality Code" [18]. The code itself is a nationally agreed, definitive point of reference for institutions that deliver or support tertiary-level academic programmes and

sets out the formal expectations that all UK higher education providers are required to meet. The document provides universities with a shared starting point for setting and maintaining the academic standards on degree programmes thereby seeking to assure the quality of the learning opportunities that are provided for students, e.g. ensuring that academic learning outcomes are comparable and consistent across the UK.

A. *Scottish HE Quality Assurance: Enhancement-Led Institutional Review*

Within the United Kingdom, Scotland has a distinctive university sector consisting of fourteen institutions with degree awarding powers. While these bodies are independent, self-governing institutions, all are funded for teaching and research through the Scottish Funding Council. Nevertheless, the qualifications that they offer and the conditions on which they are awarded are determined by the institution with degrees being legally owned by the awarding institution, not the state.

The UK QAA has a separate Scottish office, known as QAA Scotland, charged with "developing and operating quality assurance and enhancement arrangements that reflect the needs of higher education in Scotland". The main vehicle for this is the Quality Enhancement Framework (QEF) [19], a radical approach to assessing quality based on the concept of enhancement. In the context of Scottish HE, enhancement is defined as "taking deliberate steps to bring about improvement in the effectiveness of the learning experiences of students" [20] and the QEF uses a number of different strands to accomplish this. The first of these is a review mechanism called Enhancement-Led Institutional Review, which focuses on an institution's strategic approach to enhancement. One major input into this kind of review is an institutional Reflective Analysis which is meant to demonstrate the institution's capacity for self-reflection and critical evaluation in such areas as its distinctive approach to enhancement, the student learning experience, teaching and learning, academic standards and the management of academic standards..

A second key element of the Quality Enhancement Framework is the programme of Enhancement Themes. These are effectively a set of national pan-institutional educational priorities with which all Scottish institutions engage and which have produced outcomes that impact on policy and practice across the sector. These themes provide a means for all stakeholders to work together, to learn from innovative national and international practice and to promote the collective development of new ideas and models for innovation in learning and teaching. These themes last between one and three years and have included sector-wide investigation of issues such as Assessment (2003-04), Employability (2004-06), The First Year: Engagement and Empowerment (2005-08), and Research-Teaching Linkages (2006-08). The current theme (2011-14) is Developing and Supporting the Curriculum.

B. *Institution-Led Subject Review*

Alongside institutional review, there is a dual process of subject review, which, in Scotland, is carried out by the institutions themselves. While the precise nature of these reviews is determined by individual institutions, they are required by the funding bodies to maintain robust and comprehensive review activities using certain agreed features are shared across the sector. These reviews are usually carried out every five or six years. Its remit focuses solely on the learning experience of students on taught degrees and does not, for example, include evaluation of the experience of PhD students, which is reviewed by a separate process. As with the institutional review, the key piece of documentation is a Reflective Analysis, which summarises the outcomes of the School's evaluation of its enhancement activities in the area of learning and teaching provision.

It should be noted that this kind of enhancement-led approach, although consonant with the institutional quality assurance methodology, does not make explicit reference to the content of the courses. The learning objectives of the program are fully described in terms of the module descriptors for each individual subject but, from a curricular perspective, the focus of the review process is on enhancement activities undertaken by the School rather than audit of the content. This can appear to be somewhat strange given the commitment of the quality assurance agencies to competence-based quality assurance.

In practice, quality assurance of is accomplished through annual internal auditing practices together with accreditation reviews carried out by professional bodies, which is the British Computer Society in the case of Computing. Professional accreditation is sought for courses and a parallel process of review occurs with a similar length of cycle.

VI. DISCUSSION

There are similarities and differences between the three recent quality assurance efforts described, where perhaps the most profound difference is who is conducting the evaluation. The individual institutions in Sweden were clearly involved in producing the self evaluation, but the main part of the evaluation came from the panel evaluating independent project reports. This is in stark contrast to the role the institutions had in the Icelandic and Scottish evaluations. A major advantage with the latter was the close coupling to an improvement process. The self evaluations in Sweden represents an opportunity to identify areas to improve, but the result of the evaluation has little, or no, connection to the work done with the self evaluations.

Related to who is conducting the evaluation is the issue about for whom. Which is another example of where the Swedish system seem to be unnecessary limited. ENQA, for instance, criticized Sweden for focusing on results rather than providing guidance for development. Future students seem not to be stakeholders, at least not if judged by how they applied to degree programs. The bachelor program in Uppsala has the largest increase in applicants of such programs in Sweden even though it was evaluated as having inadequate quality.

The focus on outcome-based evaluation, and especially aiming at issues such as development of professional competencies, is quite interesting and challenging. Our experiences with being part of the evaluation processes show

that such evaluation is quite difficult to conduct due to inexperience with assessment of professional competencies in general. The attempt to bring the members of the evaluation panel to come up with a common view of the meaning of a learning goal such as:

be able to within the area of the degree program make judgements with regard to relevant scientific, societal and ethical aspects

proved to be quite problematic, whereas the method to tie similar learning goals to more concrete and discipline oriented descriptions provided by the ACM curricula [R4] seem to provide a better foundation for evaluation.

The cost of running the evaluations are vastly different, where costs of running the Swedish system dwarf those in Iceland and Scotland. The scope of what is being evaluated is of course also different, but Sweden comes out in poor light even if looking at the costs associated with one institution. It is interesting to note that requests to add more evaluators grading each independent project report in order to provide a better foundation for evaluation was refused due to cost reasons.

Comparing the Scottish experience with the Icelandic one, we see that there are many similarities in the methodologies of the quality assurance processes. In both cases, the independent agency that oversees the review process has a remit to pursue an enhancement-led agenda. In Scotland, this has been accompanied by a national program of activity on particular educational themes which serve to direct attention to problematic or challenging areas of the student experience and this coordinated national focus serves to enhance practice across the sector. One result of this is that quality assurance activity at the subject-level within institutions is also often focused on the Enhancement Themes.

If one considers quality assurance at the subject level, the Icelandic experience appears to be directed more towards content-based review using international benchmarks of best practice such as the ACM/IEEE curriculum. It is acknowledged, of course, that the statements of content found in these documents use outcome-based methods While the UK Quality Assurance Agency also produces benchmark statements, they play a less important role in the cycle of review for UK departments. Unlike the detailed curriculum audit undertaken by the academic staff of School of Computer Science at Reykjavik University, the formal review process for their counterparts in the Robert Gordon University does not require this. An auditing process which reviews the RGU curriculum for currency and examples of best practice does, of course, go on but, to a large extent, it is associated with the annual round of course appraisal rather than the five- or six-yearly subject review cycle. Unlike with Reykjavik University, there is a parallel process of professional body accreditation at RGU, with review cycles over a similar timescale, which, together with annual course appraisal, also feeds into the quality assessment process. The obvious question to ask is whether this type of layered approach is sufficient to ensure that the curriculum is sufficiently responsive to the needs to the various stakeholders. However, it is difficult to agree on which indicator could be measured to give a clear answer to this question.

VII. CONCLUSIONS

One important observation that can be drawn from the examples given in this paper is that recent decades have seen a radical movement away from process-based quality assurance methodologies to the outcomes-based models favoured by the proponents of the Bologna Process. This has been facilitated by the general shift amongst educators from teacher-centred pedagogical models to more student-centred models using competency-based assessment but it is also due to the perception that outcome-based performance assessment actually measures something valuable.

Outcome-based quality assurance systems that address professional competencies are valuable components in addressing the quality of our degree programs, but they have their limitations that need to be addressed. A learning outcome is dependent on many factors, where the quality of the education provided and the type of students entering the education are two crucial elements that should preferably be considered in any evaluation. From the Swedish perspective, a further point for discussion is whether a common national quality level of learning outcomes is something to strive for, or if such an aim in fact might be harmful for quality.

Despite some of the difficulties outlined in this paper, there are significant strengths in the approaches taken by each country. The emphasis on competence-based assessment as the primary mechanism by which outcome-based assurance takes place means that students are placed at the centre of the process and a focus on the learning experience is paramount when considering definitions of quality.

Finally, it is worth noting that despite the importance of quality assurance for successful educational practice, and despite significant sectoral and institutional resources being devoted to the review cycles overseen by the quality assurance agencies, research into the topic at the subject-level is uneven across disciplines. There is a large body of systematic work on the theory and practice of quality assurance in Engineering education but comparatively little on its analogue for Computing. This is somewhat surprising since both disciplines embed ideas of quality control within their technical curriculum.

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