Research on the Power of Quality Assurance in Engineering Education within Engineering Department-Case of Worcester Polytechnic Institute

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Abstract

With the advancement of the Accreditation Board for Engineering and Technology (ABET), the stakeholders of the quality assurance in engineering education have been diversified. Especially, different stakeholders involve the quality assurance in engineering education with different attitudes and behaviors. Engineering education stakeholders have formed different groups representing different powers. It will help to optimize internal quality assurance mechanisms by exploring stakeholders. Thus, this research takes Worcester Polytechnic Institute (WPI) as a case to study the power of quality assurance in engineering education from the perspective of Stakeholder Theory. The findings indicate that engineering education stakeholders have formed three main bodies representing administrative power, academic power, and student power, which play different roles and form different types of power participation; administrative power participates in the preparation and organization of program accreditation, participates in educational quality supervision, and guides teachers and students to participate in quality assurance; academic power participates in student learning evaluation and program continuous improvement, curriculum and teaching reform, teacher professional development activities; student power participates in the quality assurance both directly and indirectly. The engineering departments of the United States attach great importance to the collective responsibility of quality assurance in engineering education, and devote themselves to shaping the evaluation culture based on the participation of multiple stakeholders and forming a joint force for quality assurance in engineering education, which provides important enlightenment for the quality assurance in engineering education in other countries.

1. Introduction

As a type of talents cultivation, engineering education belongs to professional education, yet bears the general characteristics of higher education. However, the stakeholders involved in talents cultivation must be complex as the talents it cultivates are special. With the in-depth evolution of ABET, the stakeholders of the quality assurance in engineering education have increasingly become diversified. Which power subjects do the stakeholders represent? Which channels and forms do these power subjects take to participate in the quality assurance in engineering education? These problems are not only practical challenges to be solved, but also theoretical problems that need to be explored urgently. Therefore, this research attempts to explore the quality assurance power of engineering education within departments, by taking WPI as a case.

WPI, located in Massachusetts, is the third private engineering university in the

United States, founded in 1864. After the end of the American Civil War, the most pressing problems faced were building houses and roads. Therefore, most schools are looking at building civil engineering departments. The original intention of the founder of WPI was to convert the military technology developed in the war into civilian use, with the goal of cultivating engineers, so the school originated from the Department of Mechanical Engineering. At present, 70% of the school is still engineering, and mechanical engineering accounts for 30%, which is still the school's signature program. WPI has long been the best school in the New England region, becoming a national university for nearly two decades and consistently ranking in the top 50-60 in the nation. After long-term practice and continuous improvement, WPI has built a multi-dimensional evaluation system and formed a continuous operation mechanism with departments as the main body. Since the 1990s, WPI has participated in the ABET accreditation many times and has accumulated rich practical experience in quality assurance in engineering education.

2. Overview of the Stakeholder Theory and its applicability in quality assurance in engineering education

The Stakeholder Theory was proposed by R. Edward Freeman in 1984. The Stakeholder Theory holds that: all stakeholders affected by the enterprise have the right to participate in the decision-making of the enterprise, managers have the fiduciary responsibility to serve the interests of all stakeholders, and the goal of the enterprise should be to promote the interests of all stakeholders, more than just shareholders' interests [1]. Stakeholders are all individuals and groups that can affect the achievement of an organization's goals, or are affected by an organization's process of achieving its goals [2]. Stakeholders and their participation are of great value to the achievement of organizational goals. After being introduced into the theoretical research of higher education, the Stakeholder Theory is mainly used as an important analytical framework.

In the context of higher education quality, stakeholders are groups with a particular interest in quality provision and output standards, including governments, employers, students, academic and administrative staff, institutional managers, incoming students and their parents, taxpayer. Therefore, it is very important to clarify the main stakeholders of higher education and their roles in quality assurance. Due to the variety of stakeholders involved in the quality assurance in higher education, there are many different classifications [3] [4] [5] [6]. For instance, Mitchell R.K. et al. analyzed stakeholders in terms of power, legitimacy, and urgency. "Power" refers to a participant's ability to exert influence in various relationships; "Legitimacy" refers to the extent to which a participant's actions are desirable, correct, and appropriate; "Urgency" refers to a participant's urgency of the claim to be noticed. Stakeholders in any system or organization will have at least one attribute. The stakeholders are divided into three main groups, i.e., "potential" stakeholders, "anticipatory" stakeholders, and "definitive" stakeholders. The "potential" stakeholder possesses only one of these attributes, the "anticipatory" stakeholder possesses two of these

attributes, and the “definitive” stakeholder possesses all three attributes [7]. In order to realize their respective value demands, these power subjects constantly interact. According to the research by Mitchell R.K. etc., the “definitive” stakeholders can better reflect the characteristics of engineering education quality assurance stakeholders.

Currently, the research on engineering education stakeholders in academia mainly involves the research on stakeholders and their roles in the accreditation process [8], the research on the evaluation culture of stakeholders in the accreditation process [9], and the stakeholders in the engineering education system [10]. To sum up, after the Stakeholder Theory was introduced into the field of higher education, although there are many stakeholder studies in higher education, there are few studies on the quality assurance in engineering education based on the Stakeholder Theory. In the practice of quality assurance in engineering education, the subject representing administrative power, the subject representing academic power and the subject representing student power all have clear power, legitimacy and urgency. This research believes that there are also three power groups in the quality assurance in engineering education, and the three power groups are mutually independent, mutually promoting and mutually restricting. In recent years, the main body of student power has begun to return, and a power relationship that balances with the main body of academic power and administrative power has gradually formed. To some extent, it is helpful to deeply understand the power logic of quality assurance in engineering education in colleges and universities from the perspective of Stakeholder Theory, by studying the power allocation and power participation ways of different power subjects. This research attempts to apply the Stakeholder Theory to explore the quality assurance power of engineering education, identify the power subjects, demonstrate the main functions of different power subjects, and analyze the basic pathways of different power subjects participating in the quality assurance in engineering education under the background of accreditation.

3. Subject identification of the quality assurance power of engineering education in engineering department

According to the degree of influence of different stakeholders on engineering education, the stakeholders of engineering education can be further divided into different levels. Taking the School of Electrical and Computer Engineering (ECE) at WPI as an example, the stakeholders in engineering majors mainly include: engineering students and incoming students, teachers, alumni, employers (especially recent employers of several graduates), Advisory Board Member, Graduate School and Professional School [11]. In the process of carrying out engineering education in various engineering departments, due to the differences in internal and external environments, the stakeholders of educational quality must also be different. However, when we focus on the internal quality assurance aspects of engineering education, ABET’s common accreditation criteria provide a glimpse into the stakeholder group in engineering education. In ABET’s accreditation criteria, three types of stakeholder

groups are always involved, i.e., administrators, teachers and students.

3.1 Administrative power

ABET attaches great importance to the subjectivity of administrative power in the quality assurance in engineering education. For example, Criterion 4 of the general criteria for accreditation of Bachelor's Degrees in Engineering (1986-1987 accreditation cycle) involves the teaching, scientific research, academic achievements and leadership quality of management at all levels of the department. Criterion 7 of the general criteria for accreditation of Bachelor's Degree in Engineering (2002-2003 accreditation cycle) stipulates that engineering programs must have sufficient management system support, financial support and constructive leadership to ensure engineering programs. To ensure the quality and continuity of education, there must be adequate funding to attract, maintain and provide for the continuing professional development of high-quality teachers, and there must be adequate funding sources for the purchase, use and maintenance of laboratory equipment associated with engineering education; in addition, teaching assistants and administrative agencies should also serve program education and satisfy the criteria of program accreditation. Criterion 8 of the general criteria for accreditation of Bachelor of Engineering Degrees (2008-2009 accreditation cycle) stipulates that engineering programs must have adequate school support, financial resources, and constructive leadership to ensure the quality and continuity of engineering teaching.

3.2 Academic power

The quality assurance in engineering education needs to shape a collaborative and organizational academic culture. Valuable program accreditation requires the teamwork of teacher. The engineering teachers are generally self-motivated groups and tend to work completely independently. The teachers always are expert in their fields, can develop research projects, and can design courses based on knowledge in the subject area. However, this organizational culture is difficult to effectively satisfy the EC2000. Under the background of program accreditation, engineering teacher begin to pay more attention to student learning outcome at the program level. Teachers must work together as a team more than ever. A successful program will help shape an inclusive and equitable environment. In small programs, teachers can work as a whole. In larger programs, the dialogue between teachers will become increasingly complex. However, with sufficient and diverse teacher participation, guided by an evaluation committee, this dialogue can be effective and have important implications. In order to further effectively achieve teacher cooperation, the evaluation committee needs to work closely with the curriculum committee.

3.3 Student power

"Student-centered" teaching is one of the educational philosophies followed by

colleges and universities. The main function of the school is to maximize the role of the student in teaching. “student-centered” teaching is the foundation of the survival and development of colleges and universities, and individualized education for students is the embodiment of the school’s characteristics. Taking WPI as an example, “student-centered” teaching is the basic educational philosophy of the “WPI Plan”. Under the guidance of the “student-centered” teaching, students have the initiative to participate in the teaching process, have the awareness of participating in the quality assurance in engineering education, and establish the dominant position in the education process [12].

4. The function shaping of the quality assurance power of engineering education in engineering department

4.1 The function of administrative power

ABET has always attached importance to the role of administrative management in the quality assurance process of engineering education. Taking WPI-ECE as an example, the exercise of administrative power is mainly through the University President’s Office, the Office of the Provost, and the Office of the School of Engineering. Administrators support ECE and staff in different ways. The provost is responsible for monitoring all departments. The Vice Provost for Graduate Studies has less influence on undergraduate programs and accreditation, but plays an important role in supporting undergraduate and graduate programs, and in improving and supporting pathways to intellectual learning for students with career potential. The Vice Provost for Academic Affairs supports course evaluations, learning outcome evaluations, surveys, and other aspects of course quality control, and works with department chairs to ensure teaching excellence. The dean responsible for undergraduate study is mainly responsible for the quality and effectiveness of undergraduate programs, cares about the vital interests of teachers and students, and guides the development of new programs. The Associate Dean responsible for first-year teaching is not a very important role, but provides support to ECE as needed.

4.2 The function of academic power

The quality assurance in engineering education needs to select suitable teacher and give full play to their value. Program accreditation is a task that takes a lot of time and effort. To successfully conduct program accreditation, outcome evaluations require a leader at the program level. In larger schools, there is usually a core teacher or staff member responsible for promoting program evaluation, or college-level managers are responsible for coordinating ABET accreditation. However, the responsibilities of these people are far from the responsibilities of curriculum decision-making. Each program needs an elite teacher to be responsible for coordinating the evaluation work, and have continuous free time to do this work. Appointees to program evaluation

work require the participation of teacher and administrators. So, how should the appropriate teachers be selected to be responsible for the evaluation work? Every college does it differently. For example, some colleges and universities appoint a young teacher who is working hard to be promoted to tenure, and some colleges and universities will appoint an old teacher with rich experience but on the verge of retirement. Neither approach is desirable. Young teachers should be committed to research and teaching, as well as to tenure-track careers. While younger teachers may be more competent and motivated to advance evaluation efforts, the influence of older teachers is often lacking. Mature teachers often have the experience and vision to guide evaluation work, but lack the motivation to innovate. A relatively good option is to appoint mid-career, tenured and experienced teachers. Such teachers are often able to not only devote themselves to program evaluation work, but also continue to engage in program evaluation work for a period of time after the announcement of ABET's on-site inspection results. [13]

4.3 The function of student power

Since the 1990s, the main EC2000 accreditation criteria launched by ABET is "outcome-oriented". "Outcome-oriented" principle is an important transformation in the philosophy of program accreditation "from emphasizing input to emphasizing outcome, from emphasizing the teaching and research achievements of famous teachers and top students to outcome of all graduates, from emphasizing only schools teaching to the combination of theory and practice, from pure on-campus learning to on-campus learning combined with industry and social learning" [14].The "outcome-oriented" evaluation paradigm has triggered two distinct changes in relation to students. First of all, teacher pays more attention to the professional ability of students in terms of the evaluation criteria of students' learning outcome. Second, teacher pays more attention to student feedback in the technical aspects of student learning outcome assessment. In professional curriculum like engineering, incorporating student feedback into the academic quality assurance process is a common tool. Student feedback can be used not only to evaluate curriculum quality, but also to improve the overall quality of engineering classrooms, engineering practices, engineering equipment, and the engineering education environment. In addition, student feedback can enhance an institution's reputation in an increasingly globalized education market. Research on quality assurance in higher education includes a variety of advanced student feedback tools and methods.

5. The participation ways of quality assurance power in engineering department

5.1 The participation of administrative power

In the program accreditation process, administrators intervene in different ways. The first way is to participate in the preparatory for program accreditation. Successful program accreditation depends on how the leadership roles of program heads,

department chairs, deans, and core administrators are defined. In a larger department, it is impossible for the program head to solve the problem of resource allocation without the support of the department chair. However, it is also impossible for department chair to fully address the issues raised by courses, which are for the entire college rather than the department. In this case, the dean is an appropriate administrator for the leadership role. The second way is to participate in the quality supervision of engineering education. Most of colleges and universities have established internal quality assurance system in the United States, established a well-structured management structure of educational evaluation, and carried out educational evaluation work extensively at all levels. However, a large part of the work is carried out at the departmental level, and educational assessment at this level is the most important. The dean of the School of Engineering and the chairs of various departments are important members of the teaching supervision committee and have the responsibility to participate in the supervision of educational quality. The standardization and institutionalization of educational supervision work depends on the strong support and active participation of the leadership. The third way is to lead teachers to participate in educational quality assessment. In order to thoroughly implement the philosophy of "continuous quality improvement", colleges and universities have adopted administrative power to launch positive measures. For example, experts are invited to the school to carry out training on learning outcome assessment; experts with social science background are hired to design the assessment process; excellent teachers are introduced to take the initiative to undertake the task of learning outcome assessment; financial support is provided to encourage teachers to participate in the thematic Seminars and annual academic conferences; relevant seminars are organized to share advanced experience in outcome assessment. In addition, colleges and universities improve the efficiency of educational quality assurance by providing resources and financial support. On the one hand, colleges and universities will investigate the resources and their use in accordance with the requirements of EC2000, and actively carry out rectification. On the other hand, colleges and universities will actively update and upgrade resources and facilities to better promote the development of educational quality assessment.

5.2 The participation of academic power

The main ways for academic power to participate in the quality assurance in engineering education include: participating in guiding the development of engineering programs, participating in the development of engineering education goals and student learning outcomes, and carrying out engineering program assessment and continuous improvement. Among them, participating in the assessment and continuous improvement of engineering programs is the biggest challenge for teacher. According to the findings of *Engineering Change*, the potential impact of EC2000 on student learning includes three aspects - curriculum, teaching methods, and teacher culture. [15] These are actually important aspects of academic power participating in the quality assurance in engineering education. EC2000's

emphasis on student learning outcome and continuous improvement assessment requires teacher to actively improve the educational program and students' learning outcome. The first way is to participate in student learning evaluation and program continuous improvement. EC2000 requires engineering programs to evaluate student performance according to 11 learning outcomes, and use the evaluation results for program improvement. Program heads say these practices have received strong support from teacher. In addition, in order to share and master advanced engineering education evaluation theories, tools and methods, teacher also actively carry out relevant research on the quality assurance in engineering education teaching. Encouraging teacher to "embed" evaluation activities in teaching and use evaluation results to continuously reflect and improve teaching, has laid the cornerstone of the success of this quality reform movement[16]. The second way is to participate in curriculum and teaching reform. Participation in curriculum reform and development is another dimension of continuous improvement. As teachers strive to provide opportunities for students to learn and practice teamwork, engineering design and communication skill, one might also expect EC2000's emphasis on professional competencies to lead to changes in teaching methods. In practice, many colleges and universities are actively reforming teaching methods, and give full play to the role of "Problem-based Learning" and "Cooperative Learning" in meeting EC2000 criteria. The third way is to participate in teacher professional development activities. Learning how to evaluate or incorporate self-directed learning approaches into curricula may also influence teacher's engagement with teaching-focused professional development opportunities that may contribute to curriculum and instructional reforms.

5.3 The participation of student power

With the support of relevant policies, engineering students have a variety of ways to participate in the quality assurance in engineering education. According to the legitimacy of students in higher education quality assurance activities, some scholars divide this participation of students into "institutional participation" and "non-institutional participation".[17] "Institutional participation" refers to "students formally participate in various activities within the mechanisms of higher education quality assurance under the institutional regulations, and the principles, methods and procedures of their participation have been recognized by relevant institutions or organizations. It is a kind of participation activity within the framework of the existing quality assurance system. "Non-institutional participation" refers to "students' participation activities outside the framework of the existing quality assurance system, and is a kind of participation that overflows the existing norms and systems". Among them, "institutional participation" is the main way for students to participate in the quality assurance of education, and it is also an important way for students to participate in the quality assurance in engineering education. According to the different mechanisms of student participation in quality assurance, it can be divided into "institutional direct participation" and "institutional indirect

participation".

(1) Institutional direct participation

"Institutional direct participation" refers to a way in which students directly participate in the quality assurance of higher education in accordance with the principles, methods and procedures formulated by relevant systems. In terms of the effectiveness of participation, "institutional direct participation" is the most effective and direct path for students to participate in the quality assurance of higher education. [18] From the perspective of students' direct institutional participation in engineering education quality assurance, it mainly includes participating in normal teaching evaluation activities, information survey activities of engineering departments/programs, evaluation activities responding to the program accreditation of engineering education, and evaluation activities in the program accreditation of engineering education etc. The first way is to participate in normal teaching evaluation activities. Most colleges and universities in the United States have established a sound internal quality evaluation system, which provides a good institutional foundation for the quality assurance in engineering education. As far as the teaching evaluation of engineering education quality is concerned, it is more reflected in the program and course evaluation of engineering departments.

The second way is to participate in the information survey activities of engineering departments/programs. Taking the School of Electrical and Computer Engineering (ECE) of WPI as an example, ECE mainly obtains feedback information from students through student groups and course evaluations. ECE department chairs and teacher adopt an "open door" policy to further ensure that issues of student needs and cares receive immediate feedback. Data obtained from students can also be obtained through the following channels: EBI surveys (Educational Benchmarking, Inc.), annual surveys for recent graduates, special surveys.

The third way is to participate in the evaluation activities for the program accreditation of engineering education. Taking the School of Engineering of the University of Washington as an example, in order to meet the requirements of EC2000, the evaluation methods adopted by each department/program are different, which can be classified into several categories [19]: survey, scoring, feedback/evaluation/interview, courses assignment, standardized tests, capstone design courses, and more general evaluation methods mainly include surveys, feedback/evaluation/interviews, and scoring. Among them, the evaluation tools of the Department of Chemical Engineering include: surveys, teacher seminars, campus summits, and comprehensive program evaluations.

The fourth way is to participate in assessment activities in the program accreditation of engineering education. The way students participate in quality assurance in engineering education is more directly reflected in the assessment activities that

participate in the program accreditation of engineering education. During the ABET accreditation process, an on-site inspection is usually conducted by an external panel of accreditation experts. In order to ensure that students can truthfully feedback the educational quality information of program, the discussions of accreditation team and students are conducted separately. Oral feedback of educational quality information of program to accreditation experts is an important way for students to express their interests and intervene in the quality assurance in engineering education.

(2) Institutional indirect participation

"Institutional indirect participation" refers to a way in which students indirectly feedback the information of higher education quality to the government, universities or relevant departments through other activities other than quality assurance activities, and promote the improvement of higher education quality. The way is a beneficial supplement to the direct participation of students in the system, and an important way for students to participate in the quality assurance in higher education. From the perspective of the institutional indirect participation of students in the quality assurance in engineering education, it mainly includes participation in EBI survey, National Survey of Student Engagement (NSSE） and National Student Satisfaction Study (NSSS). Among them, the EBI survey and NSSE are two national surveys frequently used by engineering programs to provide information on the learning outcomes of recent graduates and information on alumni pursuing engineering careers.

The first way is to take the EBI survey. The EBI survey evaluates the effectiveness of engineering programs primarily from the perspective of students. The rated program will know which aspects are dominant and which aspects need improvement. The assessed program will promote and sustain its own continuous improvement. EBI offers three surveys: outcome evaluation, alumni evaluation and employer evaluation. [20] The second way is to participate in the NSSE. NSSE is a nationwide survey conducted at the institutional level for freshmen and seniors. NSSE obtains information on learning, classroom and school activities, expectations for improving learning. Universities are encouraged to use the NSSE findings to provide more transparent information on school quality, and in doing so improve school quality. [21] In this sense, NSSE can also be used as means of assessment. The third way is to participate in the NSSS. In American colleges and universities, there are many different forms of student satisfaction surveys, among which the most prominent and largest is the NSSS. The NSSS measures students' perceptions of the importance and satisfaction of their college experience to identify the factors that actually affect students' academic achievement. Due to the wide scope, large coverage and large number of participants, the NSSS results represent the basic situation of college students' satisfaction to some extent.

6. The Characteristics and enlightenment of the quality assurance power of

engineering department

6.1 Collective responsibility for quality assurance in engineering education

The quality assurance in engineering education is a systematic project, which is a process of continuously integrating the work of colleges and various departments. An important aspect of systemic reform is the transition from emphasizing “individual teacher’s interests, motivation, and behavior” to “teacher’s collective interests, motivations, and behaviors”. [22] The program accreditation of engineering education cannot exaggerate the responsibility and role of individual teachers, but pay attention to the importance and necessity of collective responsibility. In the process of quality assurance in engineering education, this collective responsibility is reflected in the actual work of college deans, department chairs, ABET liaisons, teachers and teaching assistants, etc. Academic power on behalf of teachers, administrative power on behalf of administrative management, and student power on behalf of students must properly participate in this systematic project in order to fulfill collective responsibilities. If the administrative power, academic power and student power are analyzed in terms of strength and weakness, four ideal models of quality assurance in engineering education may be formed in practice according to their fluctuations and different combinations, i.e., professional model, administrative model, autonomous model and collaborative model. The professional model focuses on the improvement of academic power. The administrative model focuses on the joint role of administrative power and academic power. The autonomous model focuses on the synergy of academic power and student power, and weakens the excessive interference of administrative power in quality assurance work. The collaborative model focuses on the full participation of various powers, and effectively integrates the three powers into the quality assurance process. Obviously, the power participation in the quality assurance in engineering education in American colleges and universities is mainly “autonomous” and “collaborative”, and more and more attention is paid to the “collaborative” power participation in the quality assurance in engineering education.

6.2 Cultural construction for quality assurance in engineering education

The continuous quality improvement of engineering education in colleges and universities relies on the program accreditation of ABET, on the program evaluation of institutional accreditation, and on the internal quality assurance of academic institutions. In the increasingly complex ecological environment of engineering education, the mission of engineering education in colleges and universities is increasingly far-reaching and important. The subjects of accountability and evaluation of the engineering education quality have gradually become more diversified, including not only the “external multiple subjects” composed of program accreditation agencies and institution accreditation agencies and their professional evaluators, but also the “internal multiple subjects” composed of administrators, teachers, students and parents. In the engineering education reform in the United

States over the years, students, teacher and courses are all key factors. Among them, students are undoubtedly important stakeholders. Every major engineering education reform revolves around talent cultivation. EC2000 reform puts the focus of accreditation directly on students' learning outcome. By its very nature, it is a question of how to adequately guarantee group participation. Although the "student-centered" or "student-oriented" educational philosophy is one of the basic educational concepts pursued by American colleges and universities, more responsibility for the quality assurance in higher education, especially the quality assurance in engineering education, should be attributed to engineering departments. The administrators and teachers have to resort to administrative and academic powers. The depth and breadth of students' right to participate in the quality assurance in engineering education varies from school to school. Although students have little knowledge of ABET accreditation and its standard requirements, this does not prevent students from participating in quality assurance practices. In the practice of quality assurance in engineering education, how to scientifically locate the value of student power, and how to reasonably balance academic power, administrative power and student power are important issues that colleges and universities need to consider urgently.

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