Continuous Improvement and Optimization of Curriculum System for Engineering Education Accreditation: A Questionnaire Survey on Achievement Degrees of Graduation Requirements

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Abstract: Engineering education accreditation represents the current trend in undergraduate reformation. Curriculum system improvement is an important way to realize the “innovation leading” of engineering education accreditation. However, there is little information detailing the improvement and optimization of the curriculum system for engineering education accreditation, and a method was tentatively developed based on evaluated achievement degrees of graduation requirements through a questionnaire survey in this work. The results show that a curriculum system guided by engineering education accreditation greatly improves graduation requirement achievement and students’ overall qualities. The graduation requirement achievement degree is largely influenced by the curriculum system and extracurricular science and technology activities, while it is not significantly correlated with students’ scores. Some measures are provided to optimize and improve the curriculum system, including adding additional curricula, converting the supporting index of the curriculum, strengthening the supporting degree of the curriculum, and guiding extracurricular scientific activity. Such measures are significant for increasing achievement degrees, reasonably balancing teaching resources and developing students’ comprehensive abilities. Moreover, the students’ scores cannot objectively reflect the graduation requirement achievement degree, and there exist some limitations to evaluating graduation requirement achievement degrees using course scores. Additionally, post-graduate environment factors, such as major-related work, technical work and further education, also affect graduation requirement achievement degrees.  

Keywords: engineering education accreditation; graduation requirement; achievement degree; influencing factor; curriculum optimization

1. Introduction

Engineering has a widespread and profound effect on human society and the natural environment, which is a great issue regrading global sustainable development. Higher engineering education shoulders the talent cultivation of senior engineering technicians, and its development is significant for future industrial technology and sustainable development. Economic globalization has promoted engineering globalization and the globalization of higher engineering education, and higher engineering education is heading towards openness and internationalization.

Currently, engineering education accreditation represents an important approach to engineering education reformation, combining engineering education with industry and enterprise, and international mutual recognition of engineering education [1].
“Washington Accord” is a well-known internationally accredited accord related to the professional accreditation of bachelor of engineering degrees and international mutual recognition. As one of the most authoritative, international and systematic accords for engineering education accreditation, the “Washington Accord” has been widely implemented in countries as the United States, Canada, Australia, Germany, New Zealand and Japan [2,3]. The “Washington Accord” has also been an important reference object for constructing engineering education systems worldwide [4–6]. China was enrolled as a provisional member of the “Washington Accord” in 2013, and became its 18th Member State in 2016. Since the China Engineering Education Accreditation Association (CEEAA) was authorized by Ministry of Education of China in 2006, it has undertaken the pilot work of engineering education accreditation [7,8], certifying 2899 majors in China up to the first half of 2022, covering 87 majors on 23 engineering major programs, such as Engineering, Instrument, Material and Electronic Information [9]. Engineering education accreditation requires not only the essential theoretical knowledge and technology skills, but also a global vision, consciousness of the rule of law, ecological consciousness and environmental protection awareness, design and engineering thinking, project management, communication and lifelong learning [10,11]. Therefore, engineering education accreditation represents the current trend of higher education reform.

The outcome-based education (OBE) approach has been adopted for engineering education accreditation [12]. OBE starts by defining the outcomes required by the stakeholders, including the Program Education Objective (PEO), Program Outcomes (PO) and Course Outcomes (CO). Various measurement methods are used to evaluate the outcomes attained by students. The shortcomings are addressed, and further improvements are devised based on the evaluation. This process continues until a sufficient level of attainment is met for all outcomes [12,13]. As one of the seven general standards for engineering education certification of the “Washington Accord”, graduation requirements set the specific parameters for graduate knowledge, ability and professionalism. Graduation requirements are the goal orientation of engineering education accreditation, and are also the key to attaining training objectives [14,15]. Graduation requirements are the basis for constructing a curriculum system, planning teaching targets, organizing teaching contents and contemplating teaching approaches [16]. Therefore, it is of great importance for engineering education to construct a curriculum system based on the demands of graduation requirements. However, most of the curriculum systems are subjectively constructed according to the indexes of graduation requirements, and the curriculum systems are not linked to the achievement degrees of graduation requirements.

“Continuous improvement” is one of the core principles of engineering education accreditation [17]. The periodic adjustment of the curriculum system based on the evaluation of graduation requirement achievement is just a reflection of “continuous improvement”. Thus, evaluating the achievement degree of graduation requirements is a core principle of engineering education accreditation, and is also the main reference for the adjustment of the curriculum system and an important approach to evaluating the training objectives [18]. However, there are still no uniform and mature evaluation methods of graduation requirement achievement. Generally, the evaluation methods include direct evaluation and indirect evaluation. Traditionally, direct evaluation was performed using course scores [19,20], calculated using a weighted sum of curriculum target values and their weights [20]. This approach widely prevails, such as at the University of California, Saint Louis University, and the Northern University of Malaysia [21]. In addition, some other score-based methods have also been discussed, such as the analytic hierarchy process (AHP), the fuzzy mathematics method and outcome-based assessment [12,22,23]. Wu et al. [24] established a multi-parameter classification evaluation mechanism and applied it at Xiamen University. Wang et al. [25] proposed a cumulative distribution calculation method assuming that student scores are characterized by normal distribution. These score-based approaches can evaluate technical indexes of graduation requirements, but struggle to evaluate non-technical indexes, such as teamwork, communication, professional norms, lifelong learning,
individuals and teams. Meanwhile, different instructors and teaching groups have different opinions regarding the supported indexes of courses for the graduation requirements because of the subjective cognition. Thus, there exist some limitations to evaluating graduation requirement achievement using course scores. The previous research also indicated that score-based evaluation does not match the actual quality that students attained [26–28]. Moreover, previous reforms mainly focused on the content construction of a single course, and not on the curriculum system. Furthermore, the influencing factors of graduation requirement achievement have seldom been discussed. The questionnaire survey, one of the indirect methods, has become an important method to evaluate the achievement degrees of graduation requirements by combining evaluations from industry enterprises, employees and students. Consequently, questionnaire surveys can be used to evaluate non-technical indexes. However, there has been no attempt to analyze influencing factors and construct a curriculum system according to the evaluated graduation requirement achievement degrees through questionnaire surveys.

Based on the previous information, questionnaire surveys of graduation requirement achievement from internal students, alumni and industry enterprises were performed. The main contributions of this study are summarized as follows:

− Evaluating the achievement degrees of graduation requirements using questionnaire surveys;
− Discussing the influencing factors of graduation requirement achievement degrees;
− Adjusting and establishing the rational curriculum system for engineering education accreditation based on the investigated information. In this way, it is expected to explore new continuously improving methods and add some experiences for the supporting curriculum system of graduation requirements in Chinese universities based on the provided information.

2. Research Method

A questionnaire survey was used for this research, and Hydrology and Water Resource Engineering in our university was taken as the study object. The investigated objects include the internal students (Class of 2019, C.2019), alumni (Classes of 2012 and 2016, C.2012 and C.2016) and employers. The courses for C.2012 were set without reference to the standard of engineering education accreditation, and those for C.2016 and C.2019 referred to it. The courses for C.2019 were adjusted based on those for C.2016 and the achievement degrees. There are 12 graduation requirement indexes for this major, including Engineering Knowledge, Analysis of Issues, Design/Development Solutions, Research, Applying Modern Tools, Engineering and Society, Environment and Sustainable Development, Professional Norms, Individuals and Teams, Communication, Project Management, and Lifelong Learning [14,29]. The graduation requirements one-to-one correspond to the 12 general standards of engineering education accreditation. The questionnaire was designed by asking the question “How do you rate your score for the achievement degree of this index on a scale of 0 to 10?”. The investigated students and employers were required to score the achievement degree of every graduation requirement index on a scale of 0 to 10. As the score increases, so does the achievement degree. A score of 0 represents the lowest achievement degree, with 10 being the highest. A score of 6 represents the minimal threshold to be considered successful completion of the requirements. The averages of graduation requirement achievement degrees for every class were calculated.

In total, 147 questionnaires were obtained, including 41 (27.9%) from the students of C.2012, 46 (31.3%) from the students of C.2016, 50 (34%) from the students of C.2019, and 10 (6.8%) from employers. For alumni students (C.2012 and C.2016), 49 (56.3%) have undergraduate experience and 38 (43.7%) have postgraduate experience, 55 (63.2%) gained a primary title and 32 (36.8%) gained an intermediate grade and above, and 38 (43.7%) engage in management work and 49 (56.3%) engage in technical work (Table 1).
Table 1. Basic information of respondents.

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<thead>
<tr>
<th></th>
<th>Number</th>
<th>Percentage (%)</th>
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<tr>
<td><strong>Total respondents</strong></td>
<td></td>
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<tr>
<td>C.2012</td>
<td>41</td>
<td>27.9</td>
</tr>
<tr>
<td>C.2016</td>
<td>46</td>
<td>31.3</td>
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<tr>
<td>C.2019</td>
<td>50</td>
<td>34</td>
</tr>
<tr>
<td>Employers</td>
<td>10</td>
<td>6.8</td>
</tr>
<tr>
<td><strong>Alumnus students</strong></td>
<td></td>
<td></td>
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<tr>
<td>(C.2012 and C.2016)</td>
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<tr>
<td><strong>Education experience</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undergraduate</td>
<td>49</td>
<td>56.3</td>
</tr>
<tr>
<td>Postgraduate</td>
<td>38</td>
<td>43.7</td>
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<tr>
<td><strong>Professional title</strong></td>
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<tr>
<td>Primary title</td>
<td>55</td>
<td>63.2</td>
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<tr>
<td>Intermediate grade and above</td>
<td>32</td>
<td>36.8</td>
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<tr>
<td><strong>Work engaged in</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management work</td>
<td>38</td>
<td>43.7</td>
</tr>
<tr>
<td>Technical work</td>
<td>49</td>
<td>56.3</td>
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SPSS 22.0 software was used for statistical analysis. The Cronbach’s alphas for the Class of 2012, 2016, 2019 and employers were 0.918, 0.925, 0.968 and 0.76, respectively. All the Cronbach’s alphas were above 0.7, indicating good credibility.

3. Results of the Graduation Requirement Achievement Degrees

3.1. The Evaluation of Achievement Degrees of Graduation Requirements

The achievement degrees of graduation requirements of students in C.2012, C.2016, C.2019 and the employers have ranges of 5.85–7.71, 7.15–8.35, 7.3–8.65 and 7.1–8.4, with averages of 6.83, 7.51, 7.75 and 7.68, respectively (Table 2). All the graduation requirement indexes have achievement degrees of more than 6, except for “5. Applying Modern Tools” of C.2012 (slightly less than the threshold value of 6), which indicates the general achievement of goals. Overall, the indexes of “7. Environment and Sustainable Development”, “8. Professional Norms” and “9. Individuals and Teams” have relatively higher achievement degrees, and those of “4. Research” and “5. Applying Modern Tools” have relatively lower achievement degrees. This means that the curricula supporting the graduation requirement indexes of “4. Research” and “5. Applying Modern Tools” should be strengthened.

The correlations of graduation requirement achievement degrees of different classes are shown in Figure 1. There exists a significantly positive correlation (p < 0.01) between the graduation requirement achievement degrees of C.2016 and those of C.2019 (R² = 0.7783). This may be because the supporting courses of both C.2016 and C.2019 referred to the standards of engineering education accreditation, and their achievement degrees were governed by the same factor—engineering education accreditation. However, there exists no significant positive correlation between those of C.2012 and those of C.2019, possibly because the courses for C.2012 did not refer to the standards of engineering education accreditation. Additionally, the graduation requirement achievement degrees of employers were also found to be significantly positively correlated with those of C.2016 and C.2019 (R² = 0.5781 and 0.6113), which illustrates the concordance between the employers’ and the students’ evaluation of these tasks. Meanwhile, the relatively lower coefficients (R² = 0.5781 and 0.6113) indicate the differences between evaluated values provided by employers and the students.
Table 2. Statistical results of achievement degrees of graduation requirements.

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<tbody>
<tr>
<td>C.2012</td>
<td>7.68</td>
<td>6.49</td>
<td>7.00</td>
<td>6.95</td>
<td>5.85</td>
<td>7.05</td>
<td>7.71</td>
<td>6.83</td>
<td>6.15</td>
<td>6.46</td>
<td>7.10</td>
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<tr>
<td>C.2016</td>
<td>7.30</td>
<td>7.43</td>
<td>7.37</td>
<td>7.28</td>
<td>7.15</td>
<td>7.65</td>
<td>7.80</td>
<td>8.35</td>
<td>7.78</td>
<td>7.32</td>
<td>7.30</td>
</tr>
<tr>
<td>C.2019</td>
<td>7.45</td>
<td>7.65</td>
<td>7.36</td>
<td>7.30</td>
<td>7.38</td>
<td>7.62</td>
<td>8.08</td>
<td>8.65</td>
<td>8.20</td>
<td>7.68</td>
<td>7.55</td>
</tr>
<tr>
<td>Employers</td>
<td>7.8</td>
<td>7.5</td>
<td>7.1</td>
<td>7.1</td>
<td>7.7</td>
<td>8.0</td>
<td>7.9</td>
<td>8.4</td>
<td>7.9</td>
<td>7.5</td>
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Figure 1. Correlations of graduation requirement achievement degrees.
3.2. The Influencing Factors of Graduation Requirement Achievement Degrees

The Pearson correlations of achievement degrees with student scores are shown in Table 3. The scores of students of C.2012 show a positive correlation ($p < 0.05$) with the evaluated values of “3. Design/Development Solutions”, “4. Research”, “6. Engineering and Society” and “10. Communication”, but with low coefficients of 0.336, 0.331, 0.344 and 0.366, respectively. The scores of students of C.2016 are significantly positively correlated ($p < 0.01$) with the indexes of “4. Research” ($r = 0.472$), “6. Engineering and Society” ($r = 0.434$), “8. Professional Norms” ($r = 0.431$) and “12. Lifelong Learning” ($r = 0.383$), and positively correlated with the indexes of “7. Environment and Sustainable Development” ($r = 0.354$) and “10. Communication” ($r = 0.361$). The only positive correlation ($p < 0.05$) with the scores of students of C.2019 is observed for “8. Professional Norms” ($r = 0.332$). Generally, the weak correlations and low coefficients indicate the scores have little relationship with the evaluated values.

The evaluated achievement degrees by the students frequently participating in extracurricular scientific activities (ESA) are observed to be obviously higher than those not participating in extracurricular scientific activities (NON-ESA) (Figure 2). Different indexes of graduation requirements have different degrees between ESA and NON-ESA. The indexes of “6. Engineering and Society”, “9. Individuals and Teams” and “10. Communication” have increased ranges of more than 0.5, those of “2. Analysis of Issues”, “3. Design/Development Solutions”, “11. Project Management” and “12. Lifelong Learning” increased with ranges between 0.3 and 0.5, and those of “7. Environment and Sustainable Development” and “8. Professional Norms” have increased ranges of less than 0.1. Therefore, extracurricular scientific activities appear to have a great effect on students’ abilities relating to teamwork, social responsibility, communication and consultation, analyzing and solving problems, and independent learning, while extracurricular scientific activities contribute relatively less to the level of engineering ethics. It is of great significance to integrate extracurricular scientific activities into the cultivation of talents for the improvement of graduation requirement achievements and achieving training goals, especially the level of engineering knowledge and engineering practice.
Table 3. Correlations between student scores and achievement degrees of graduation requirements.

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</thead>
<tbody>
<tr>
<td>C.2012</td>
<td>0.214</td>
<td>0.3</td>
<td>0.336 *</td>
<td>0.331 *</td>
<td>0.275</td>
<td>0.344 *</td>
<td>0.241</td>
<td>0.16</td>
<td>0.167</td>
<td>0.366 *</td>
<td>0.293</td>
<td>0.195</td>
</tr>
<tr>
<td>C.2016</td>
<td>0.148</td>
<td>0.212</td>
<td>0.113</td>
<td>0.472 **</td>
<td>0.286</td>
<td>0.434 **</td>
<td>0.354 *</td>
<td>0.431 **</td>
<td>0.087</td>
<td>0.361 *</td>
<td>0.111</td>
<td>0.383 **</td>
</tr>
<tr>
<td>C.2019</td>
<td>0.082</td>
<td>0.258</td>
<td>0.089</td>
<td>0.075</td>
<td>0.225</td>
<td>0.27</td>
<td>0.138</td>
<td>0.332 *</td>
<td>0.266</td>
<td>0.124</td>
<td>0.048</td>
<td>0.207</td>
</tr>
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* means significant correlation at 0.05 level; ** means significant correlation at 0.01 level.

Figure 2. Relationship between extracurricular scientific activities and achievement degrees of graduation requirements.
The training objectives are the expected abilities that students should have attained 5 years after graduation, and the realization of training objectives is based on the achievement degrees of graduation requirements [3,14]. So, the students of C.2016 are taken as an example to discuss the effect of post-graduation environmental factors on the achievement degrees of graduation requirements (Figures 3–5). The students engaged in major-related work have increased achievement degrees compared with those not engaged in major-related work, with increasing ranges of 0.35–1.54 and average of 1.03 (Figure 3). This indicates that engaging in major-related work helps the achievement of training objectives and graduation requirements. Figure 4 presents the difference in evaluated achievement degrees of graduation requirements by students engaged in management works and by those engaged in technical works. The evaluated achievement degrees of indexes of “1. Engineering Knowledge” and “4. Research” by students engaging in management works display no obvious difference from those engaging in technical works. The evaluated achievement degrees of other indexes by students engaging in technical work are generally higher than those by students engaging in management work except for the index of “5. Applying Modern Tools”, especially with the increasing range of more than 1.0 of “3. Design/Development Solutions”, “11. Project Management” and “12. Lifelong Learning”, indicating that technical work strengthens students’ abilities regarding resolving problems, professional norms, management and relearning. Figure 5 compares the evaluated achievement degrees of graduation requirements by students with further education and those without further education. The achievement degrees of indexes of “1. Engineering Knowledge”, “2. Analysis of Issues”, “4. Research”, “5. Applying Modern Tools”, “6. Engineering and Society”, “7. Environment and Sustainable Development”, “10. Communication” and “12. Lifelong Learning” among students with further education are significantly higher than those among students without further education, which is closely related to re-education and relearning. So, the effect of post-graduation environmental factors on graduation requirement achievement should be noted. It also seems that post-graduation environmental factors contribute to all aspects of graduation requirement achievement.

![Figure 3. Relationship between achievement degrees of graduation requirements and major-related work.](image_url)
Figure 4. Effect of technical work or management work on achievement degrees of graduation requirements.

Figure 5. Effect of further education on achievement degrees of graduation requirements.

4. Continuous Optimization and Improvement Measures of Curriculum System and Its Application Results

The evaluation of achievement degrees of graduation requirements is the basis for the optimization and improvement of the curriculum system [13,18]. Thus, the evaluated achievement degree of every index of graduation requirements represents the supporting strength of the curriculum [30,31], and the supporting curriculum system should be optimized and adjusted regarding the indexes with low achievement degrees. In 2018, the curriculum system was adjusted according to the evaluated achievement degrees of graduation requirements of C.2016, and the details regarding the methods are as follows:

1. Adding additional curricula: Some additional curricula are added to support indexes with low achievement degrees considering training objectives and the graduation requirement indexes for this major. Meanwhile, the supporting curricula of indexes with high achievement degrees should be reduced to reasonably balance teaching resources and develop students’ comprehensive abilities in limited credits and class periods. For example, the new curricula of “Freshman Seminar”, “Basic Geology Experiment” and “Platting Practice in Hydrogeology” were added to support the index of “9. Individuals and Teams” in 2018. These curricula strengthened students’ group consciousness and collaborative spirit by allowing them to work in groups,
and the achievement degree of this index also increased from 7.78 of C.2016 to 8.20 of C.2019 (Table 2).

(2) Converting the supporting index of the curriculum: A curriculum has several instructional targets, and can support multiple indexes of graduation requirements. Thus, a curriculum can be considered to be converted to support the indexes with low achievement degrees, and the teaching content and teaching approaches are correspondingly adjusted to support the new indexes. For example, considering that the evaluated achievement degree of the index of “5. Applying Modern Tools” is relatively low, the course of “General Chemistry” was adjusted to support it in 2018. The teaching content of “General Chemistry” is renewed according to the requirement for selecting and using reasonable modern analysis techniques to solve complex engineering problems about water environments.

(3) Strengthening the supporting degree of curriculum: For the same curriculum, the supporting degrees for the indexes with low achievement degrees can be strengthened, and those for the indexes with high achievement degrees can be weakened. Accordingly, the teaching content and teaching approaches are changed. For example, to improve the achievement degree of the index of “12. Lifelong Learning”, the supporting degrees of the curricula “College English” and “Freshman Seminar” are converted from “weak support” to “strong support” for this index. The curricula are also required to renew the content emphasizing the consciousness of lifelong learning, and to improve lifelong learning skills through a literature review, personal statements and communication.

Interestingly, this investigation reveals the importance of extracurricular scientific activities on the achievement degrees of graduation requirements, especially on students’ abilities regarding resolving problems, designing, teamwork, learning and communication. So, extracurricular scientific activities should be considered integral in the cultivation of talent. Some measures were taken to guide students’ extracurricular scientific activities and improve achievement degrees for the students of C.2019, such as “combining classroom teaching and scientific activities”, “expanding students’ extracurricular scientific activities” and “substitution of extracurricular scientific activities for course credits”. In this way, the achievement degrees of graduation requirements are expected to be improved by encouraging students to participate in extracurricular scientific activities.

The comparison of achievement degrees of different classes is presented in Figure 6. The evaluated achievement degrees of indexes of “3. Design/Development Solutions”, “4. Research”, “6. Engineering and Society” obtained by students of C.2016 are roughly equal to those obtained by students of C.2019. Other indexes obviously have higher achievement degrees of C.2019 than those of C.2016, especially the indexes of “8. Professional Norms”, “9. Individuals and Teams”, “10. Communication” and “12. Lifelong Learning”. Such facts imply that the optimized curriculum system evidently promotes achievement degrees and talent qualities. In addition, the evaluated achievement degrees of graduation requirements are in the range of 7.15–8.35, indicating a balance of the indexes and the validity of this method.
Most of the curriculum systems are subjectively constructed according to the indexes of graduation requirements. Several approaches to the construction of curriculum system have attempted to meet the needs of engineering education accreditation. Zhang et al. [32] proposed a DEMATEL-AISM model to establish curriculum systems for engineering education accreditation. Wu et al. [33] constructed a curriculum system based on the TRIZ (Theory of Inventive Problem Solving) innovative approach. Shim et al. [34] showcased a design of an undergraduate Business Analytics track curriculum integrating certifications. Jin et al. [35] reconstructed the curriculum systems for engineering education accreditation according to the satisfaction of students and enterprise experts. Zai et al. [36] constructed the professional curriculum system based on the system principle and reverse design of outcome-based education. However, these methods did not link curriculum systems to the achievement degrees of graduation requirements.

The adjustment of the curriculum system is related to the modification of major cultivation programs, and such modification is uniformly organized every few years in most universities in China. The rules and regulations for investigation and evaluation methods of graduation requirement achievement degrees should be formulated. Some other conditions should also be considered when the curriculum system is constructed. For example, some practice courses cannot be developed because of the lack of funds and instrumental equipment in undeveloped areas in China. Some courses should be encouraged for their specialty characteristics.

5. Discussion

5.1. Effect of Engineering Education Accreditation on Students’ Comprehensive Qualities

Figure 6 represents the evaluated achievement degrees of graduation requirements of different classes. The curriculum for C.2012 did not refer to the standards of engineering education accreditation, and its index of “1. Engineering Knowledge” has a slightly higher achievement degree than that of C.2016 and C.2019. This may be because the curriculum system for C.2012 mainly focused on basic knowledge and skills, resulting in a high achievement degree of “1. Engineering Knowledge”. Meanwhile, other indexes for C.2012 have lower evaluated values than those for C.2016 and C.2019, especially the indexes of “2. Analysis of Issues”, “5. Applying Modern Tools”, “8. Professional Norms”, “9. Individuals and Teams”, “10. Communication” and “12. Lifelong Learning”. Such results indicate that a curriculum system referring to the standards of engineering education accreditation greatly strengthens students’ social consciousness, ethics, engineering practice, lifelong learning, communication and consultation, and engineering leadership. Engineering education accreditation focuses on students’ abilities regarding professional norms, communication and leadership and relearning, which can promote students’ comprehensive qualities [29,37,38].

The evaluated achievement degrees of graduation requirements represent the supporting degrees of the curriculum system for the index [39]. The students from C.2019 provided
higher values of graduation requirement achievement than those from C.2016 because of
the optimization and improvement of the curriculum system according to the achievement
degrees of graduation requirements in 2018 (Figure 6). The curriculum system is closely
related to graduation requirement achievements [31], and the adjusting of the supporting
curriculum system is conducive to improving the graduation requirement achievements.
This also means that this method is valid to improve graduation requirement achievement
and students’ comprehensive qualities.

5.2. Relationship between Graduation Requirement Achievements and Scores

The evaluation of graduation requirement achievement is an important link for engi-
eering education, and is also the basis for the continuous improvement and adjustment of
curriculum system [11,15]. Currently, there are still no uniform and mature evaluation meth-
ods of graduation requirement achievement [40,41]. Course score is the most commonly
used method to evaluate the achievement degrees of graduation requirements in most
countries [19–23]. The scores are commonly evaluated through final exams, tests, home-
work, classroom questioning, group discussions and test reports. Obviously, these scores
generally focus on the grasping and remembering of basic knowledge, and struggle to
reflect the ability to solve complex engineering problems. The abilities regarding teamwork,
professional norms, communication, leadership and relearning are difficult to measure
through students’ scores [3,42], especially through written exams. As a result, students’
exam scores cannot objectively reflect the achievement degrees of graduation requirements.

Our investigation also argues that only weak correlations exist between students’
scores and achievement degrees of graduation requirements (Table 3), which implies the
limitation to evaluating achievement degrees of graduation requirements based on scores.
The investigation conducted by Sheng [26] concluded that 21% of teachers and 51% of
students deemed that scores could not reflect graduation requirements and teaching targets,
and almost half of the teachers and students argued that scores could not represent students’
abilities. You [27] argued that the scores oftentimes do not match the actual qualities of the
students. A survey from students was developed and also revealed that the exit exam could
not appropriately evaluate students’ attainment of program learning outcomes [28]. Thus,
the reasonable scoring standards of courses should be established according to the target of
graduation requirements for engineering education accreditation, especially considering
the non-technical indexes of professional norms, individuals and teams, communication,
leadership and lifelong learning. Some creative evaluation methodologies were explored
and can be referenced. For example, Milwaukee School of Engineering developed rubrics
for assessing oral presentations [28]. Design work was assessed based on stakeholder
input at Brigham Young University [43]. Waterloo University presented a proposal for the
evaluation of leadership abilities [44]. Davis and Feinerman [45] developed an alternative
method to assess engineering ethics. Meanwhile, the combining of direct (exit exam
scores) and indirect (such as questionnaire survey, interview) evaluation methods may be
considered [46].

5.3. Effect of Post-Graduation Environmental Factors on Graduation Requirement
Achievement Degrees

The environmental factors during term time are always focused on when the effects
on graduation requirement achievement degrees are discussed, and there is no information
about the post-graduation environmental factors. According to the standards of engineering
education accreditation, training objectives are the expected abilities that students should
have attained 5 years after their graduation. Thus, the post-graduation environmental fac-
tors should be examined. Very interestingly, the students engaged in major-related works
have increased achievement degrees compared with those not engaged in major-related
works. The evaluated achievement degrees displayed by students engaging in technical
works are generally higher than those displayed by students engaging in management
works. The evaluated achievement degrees displayed by students with further education
are significantly higher than those displayed by students without further education. Such facts imply that post-graduation environmental factors have a great effect on the achievement degrees of graduation requirements. The tracking evaluation of graduate qualities has been periodically carried out to provide reliable feedback for teaching reform. However, the post-graduation environmental factors have not been covered when the achievement degrees of graduation requirements have been evaluated.

6. Limitation and Future Works

Reasonable evaluation of the achievement degrees of graduation requirements is an important basis for the construction of a curriculum system. Some indexes of graduation requirements cannot be accurately evaluated using students’ course scores, especially the non-technical indexes. This research provides some experiences and references to improve curriculum system for engineering education accreditation based on a questionnaire survey. However, the evaluated values are determined by the students and employers, and the evaluation is subjective to some degree, although it can reflect achievement degrees of non-technical indexes. The periodical evaluation is significant for the adjustment of course systems. So, more reasonable and scientific evaluation methods of graduation requirement achievement should be developed. Especially, comprehensive methods combining direct evaluation and indirect evaluation should be considered.

The factors which should be considered for the construction of curriculum systems are complex and multitudinous. The curriculum system is optimized only considering engineering education accreditation in this research. However, some others put forward different requirements for the curriculum system in higher education in China, such as new engineering construction, curriculum ideology and politics, engineering practice, double first-class construction, and so on. Therefore, the construction of a curriculum system should comprehensively consider these factors during the implementation process.

The curriculum system is discussed regarding the achievement degrees of graduation requirements in this research. The teaching content, teaching methods and teaching models of a single course also deeply affect the achievement degrees of graduation requirements, which is not involved in this research. Thus, teaching reforms of single courses should be focused on improving the achievement degrees of graduation requirements.

7. Conclusions

This study evaluated the achievement degrees of graduation requirements and optimized the curriculum system through questionnaire surveys from internal students, alumni and industry enterprises. The analysis showed that the curriculum system referring to the standards of engineering education accreditation resulted in higher achievement degrees. Graduation requirement achievement degrees were observed to be affected by the curriculum system and extracurricular scientific activities. This work also provided some measures to optimize and improve curriculum system, including adding additional curricula, converting the supporting index of the curriculum, strengthening the supporting degree of the curriculum, and guiding extracurricular scientific activity. Consequently, a method for the continuous improvement of the curriculum system based on graduation requirement achievement degrees was put forward. This method is proven to increase achievement degrees, balance teaching resources and develop students’ comprehensive abilities. Moreover, the post-graduation environmental factors were observed to affect achievement degrees, such as major-related work, technical work and further education. Only weak correlations exist between achievement degrees and scores, which indicates that course exam scores cannot objectively reflect the achievement degrees of graduation requirements. Thus, caution should be taken when evaluating achievement degrees using exam scores, and reasonable evaluation methods should be developed. This research is expected to provide some experiences and references to improve and optimize the curriculum system for engineering education accreditation.
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