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Research Article

Application of Sustainable Education Innovation in the Integrated Teaching of Theory and Practice Adopted in the Auto Chassis Course

Tzu-Chia Chen,[1] Jiuqi Yu,[2] and Amir-Mohammad Golmohammadi[3]

[1]*Department of Industrial Engineering and Management, Ming Chi University of Technology, New Taipei City 24301, Taiwan*
[2]*Dhurakij Pundit University, Bangkok 10210, Thailand*
[3]*Department of Industrial Engineering, Arak University, Arak, Iran*

Correspondence should be addressed to Amir-Mohammad Golmohammadi; a-golmohammadi@araku.ac.ir

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With the swift advancement of the auto repair industry, the demand for relevant talents and professionals in auto repair is thereby increasing steadily. Meanwhile, due to higher and higher expectations and requirements from contemporary society towards these professionals, it is a must to continuously reform the course teaching mode adopted for the auto repair specialists in the secondary vocational schools to adapt to the market needs ultimately. The study's primary aim was to investigate the application of sustainable education innovation in the integrated teaching of theory and practice adopted in the auto chassis course. Some research tools such as fuzzy Delphi method, fuzzy failure mode and effect analysis (FFMEA), and theory of inventive problem-solving (TRIZ) have been employed during the research process. After surveying and collecting the security incidents, which occurred in the integrated teaching of theory and practice adopted in the automobile chassis course, the presented reality that teachers were reluctant to accept the integrated teaching of theory and practice, and the deficiencies sensed in the school-enterprise engagement; the researcher firstly obtained the risk priority number (RPN) of each deficiency above via fuzzy failure mode and effect analysis (FFMEA) and accordingly expounded how TRIZ was applied under this circumstance. Furthermore, the conflicts among the enterprise, school, teachers, and students were explored in sequence utilizing technical contradiction solutions. Henceforth, three strategies were generated and proposed aimed at enhancing the integrated course teaching of theory and practice for the automobile chassis major: (1) hardware construction, involving the construction of not only the teaching workplace and teaching equipment but also teaching faculty training; (2) resource construction, along with the construction of school-based courses; and (3) improvement of classroom teaching. At the last stage, the three advancement strategies' validity was verified based on the implementation of a six-month remedial period.

1. Introduction

Due to the rapid advancement of the auto manufacturing process and technology and the growing high-tech application in modern automobile design, higher and stricter requirements have been cast on practitioners in the concerned areas, especially those engaged in vehicle body and chassis maintenance. Meanwhile, major shifts have also emerged concerning automobile maintenance's concept, methods, tools, and contents. Faced with the ceaseless improvement in both the social economy of China and the technology applied in this nation's auto repair industry, these secondary vocational schools of auto repair are pressured to update their concept of talent training, during which the concept of cultivating innovative technical talents must be highlighted [1, 2]. Besides, equal attention needs to be paid in the cultivating process to both operational and mental skills. In this case, students majoring in auto chassis maintenance are required to integrate theory and technology into practical maintenance operations as soon as possible and shorten the breaking-in period in line with their industry as best as possible [3, 4].

In recent years, the technology adopted in auto manufacturing has been experiencing an unceasing renewal alongside the perpetual update of newly designed automotive products and the fast-changing automotive technology. As the comprehensive chassis control system is advancing to more integrated, intelligent, and networked, greater and greater requirements are expected towards the chassis maintenance level. In this case, the original teaching model has landed into a predicament where it fails to adapt to the current teaching content and teaching methods. Hence, a series of drawbacks have come forth due to the monotonous teaching model where practical training teachers are responsible for the expertise operation and demonstration [5–7]. The first drawback lies in that these teachers find it almost impossible to take into account each student's need, thus making it rather difficult for all students to observe and hear clearly. Secondly, for secondary vocational students whose academic performance tends to be not so satisfying, they would feel considerably tough to master the knowledge and skills with merely one single operation demonstrated by a teacher; thus, it is not uncommon for students to make errors frequently when practicing converting the textual knowledge into practical operation. Thirdly, a high damage ratio of equipment has resulted from the lack of procedural guidance. Last but not least, book-centered teaching bias infiltrates as novel technologies could not be introduced into the conventional course teaching in a spontaneous way [8–10].

Nevertheless, the reality should never be neglected that a relatively high requirement is claimed during the practical training process with regard to the specialty of automobile application and maintenance. Amid the construction of chassis maintenance projection, an enormous investment is a precondition in purchasing and installing relevant equipment for practical training [11–13]. At the initial stage, where a series of chassis maintenance equipment such as balancing engines, tire changers, and lifting machines are essential, not only is enough space needed, but also the rest expenses are shockingly huge, not to mention the cost of related consumables in the subsequent process of practical training. It is rather challenging for secondary vocational schools, whose sufficient funding sources are normally impossible to guarantee, to cultivate qualified talents in auto chassis maintenance through the traditional training model [14–16]. To get out of the predicament, the existing practical training environment needs updating and optimizing by exploring the most suitable educational and skill training approaches based on corresponding research of the teaching characteristics manifested in auto chassis maintenance projection. Under the circumstance where the actual investment in the training environment fails to match the professional standard, the integrated research, established on both the projection's characteristics and the existing training environment, is considered the only route, on the one hand, to reform the current curriculum and, on the other, to enhance the impact of teaching and training [17, 18] significantly.

Concerning the resource system of teaching in chassis maintenance projection of auto repair, we, more often than not, simply focus on relevant courses' practical teaching resources, such as teaching venues, teaching tools, and teaching materials. However, preternaturally practical as the training projection is, its teaching resources are supposed to be "holographic," meaning that deeper exploration and broader expansion in an all-round way are urgently needed to ultimately construct a multidimensional system, such as the curriculum teaching system of information technology, the teaching system of cooperation with the auto industry, and the teaching system of coordination with professional training institutions of auto repair [5, 19]. Aside from exploring the abundant teaching resources, an appropriate combination with this course's teaching objectives is also imperative to grope for a rational mode of integration and expansion, including the organizational form, blending content, and assessment systems. To keep pace with the development trend, a growing number of secondary vocational schools in China have set about digging into an integrated teaching mode of theory and practice. To truly implement the integrated teaching mode into professional courses via the behavior-oriented approach, these organizations are committed to combining professional theoretical knowledge with operational skills, making full use of information technology, and developing serviceable courses that corresponding enterprises could adopt and to ameliorating their teaching venues. As far as the auto repair major of secondary vocational education is concerned, a feasible way of cultivating skilled talents is in dire need to ensure the gradual adaptation to the new curriculum reform and to the progress achieved in both the auto repair industry and the general society [11, 16]. Based on the research background and motivation above, the three key research tools, involving fuzzy Delphi method, fuzzy failure mode and effect analysis (FFMEA), and theory of inventive problem-solving (TRIZ), were utilized in this study. After surveying and collecting the security incidents, which emerged in the integrated teaching of theory and practice adopted in the automobile chassis course, the manifested reality that teachers were reluctant to accept the integrated teaching of theory and practice, and the deficiencies perceived in the school-enterprise engagement, the researcher obtained the risk priority number (RPN) of each deficiency above via fuzzy failure mode and effect analysis (fuzzy FMEA), followed by proposing correlated strategies about how to optimize the integrated teaching of theory and practice for the maintenance of vehicle body and chassis. Moreover, the validity of these optimizing strategies was verified based on the implementation of a six-month remedial period [7, 8, 12, 20, 21].

Overall, given fast progress of the auto repair industry, the demand for related talents and professionals in auto repair is growing constantly. Hence, this study intends to analyze and inspect the application of sustainable education innovation in the integrated teaching of theory and practice adopted in the auto chassis course. This study can contribute to reinforcing the integrated course teaching of theory and practice for the automobile chassis major.

2. Literature Review

Relevant literature is to be reviewed in this section, which has been split up into three parts, with the first part focusing on literature about the integrated teaching model of theory and practice, the second part addressing literature regarding the application of TRIZ in education innovation, and the last part probing into the related application contents of the fuzzy theory. The integrated teaching of theory and practice, which originated in Europe at the outset, has been expanding rather rapidly owing to the close attention and strong support from the local government. Having undergone long-term practice and being summarized, this teaching model has succeeded in evolving into a comparatively impeccable and practical teaching mode in vocational education. As for the "dual system" advocated in Germany, its training goal lies in that instead of systematically imparting theoretical knowledge to students, secondary vocational schools are supposed to undertake the prime mission of enabling their students to engage independently in various professional activities by imparting to student's compulsory theoretical knowledge and by providing with them practical professional training. Hence, part of the German scholars such as Walden [17], Putz [13], and Sondermann [16] attached more of their attention to "action-oriented" vocational education, which emphasizes the "key competence" and "students' comprehensive capability of independence," that is to say, students are requested to construct their own capacity system by "acquiring information, formulating plans, implementing plans, and evaluating plans all in an independent way." On the other side, this "dual system" of Germany functions almost as an embodiment of the integration of theory and practice at a relative macro-level. Meanwhile, it is not hidden that excessive reliance has been attached on enterprises in this "dual-system" model, which could lead to the marginalization of schools' role. When such "dual system" is being applied, it is the enterprises that grasp the decisive role during the integrated course teaching of theory and practice, while schools are reduced to a lower position of support. Obviously, this model is not applicable at all when it comes to the contemporary situation of the integrated teaching of theory and practice in China where school education serves as the mainstay and enterprises simply act as an assistant.

Vocational education in the United States, evolving from the vocational education concept of competency-based education (CBE), belongs to that type of model, which is "wide-range, professional, and multifunctional." For a long-lasting period, American scholars tend to fix their eyes on the investigation of the interactive integrated teaching model. Part of the scholars [8–10] are more focused on studying the integration of theory and practice from the perspective of practical teaching cases, and they opt to target these aspects as the core of practical teaching: further deepening the case teaching and strengthening students' ability to analyze and to solve problems. There are also scholars [9, 15, 18] who, after analyzing the integrated teaching from teachers' perspective, pointed out that teachers are expected to be adequately capable of combining the theoretical teaching with practical training, while at the same time trying to avoid lecturing alone for too long; moreover, sufficient attention is required in the cooperative discussion with students to address the specific problem. Regarding the teaching model of US vocational education, although more concerns are distributed to the development of teachers' quality, each teacher functions basically as a facilitator, reflecting the fact that this kind of vocational education emphasizes the subjectivity of its students, particularly the self-evaluation of students. Pitifully, this type of "self-training evaluation system" has not yet sought its hotbed in China since the entanglement of whether students should be delegated with the priority of instruction evaluation is still in suspense [4, 18].

Australia's competence-based education and training (CBET) is a state-supervised vocational education model under the market's regulation. All along a nice bit of focus has been cast on exploiting effective teaching tactics in Australia [3, 11]. In recent decades, quite a few local college scholars have attempted to carry out their research into integrated teaching strategies, primarily including thematic teaching method, interactive teaching mode, and role-playing teaching, all of which fully pertain to the integrated model associating the theory with practice. At vocational education colleges of Australia, textbooks are not set and employed in unified standards, but instead each teacher shoulders the task of selecting specific textbooks according to the actual need. Despite the great flexibility in the teaching procedure, it is rather challenging to supervise and monitor the teaching quality due to the absence of a standardized teaching basis (namely textbook). In parallel, students are facing the obstacle of lacking relatively reliable materials for self-study [12, 14].

Hereby, it can be asserted naturally that in-depth research on the integrated teaching of theory and practice has been conducted in developed countries such as Germany, the United States, and Australia, and at the same time, this type of teaching method has already been vigorously implemented in those nations. However, it is undisputed that each mature vocational education model, which has gone through constant evolution under its specific background and environment, needs to tune into various factors, involving its local economy, culture, demography, and education. In China, where few changes would be made concerning its school-based vocational education in the short term, it is unfeasible to delegate to students the right of assessing the teaching efficiency, and developing a series of unified teaching materials is requisite to cater for the form of class teaching. As a result, the allegation can be generated that the initiative of ponderously transplanting the integrated teaching model abroad into China is inconsistent with its domestic condition. To patch it up, opportune reference and absorption from foreign nations in a critical way are well worth a shot in the pursuit of the integrated teaching model, which best suits its both national and provincial conditions.

TRIZ, abbreviation in Russian of Teoriya Resheniya Izobretatelskikh Zadatch, means "inventive theory of problem-solving," which is to seek potential access to technological innovation in a systematic way. It is deemed as a powerful innovative tool as it depicts the trend of innovation through the evolutionary model of technological development. After an investigation into over 200,000 patents, it has been discovered via this tool that several ubiquitous basic problems and consistent solutions are commonly scattered among various innovative achievements in different fields [7, 13]. In other words, a single solution is applicable in addressing certain problems arising in different fields and at different times. In view of this case, the process of invention and innovation and the problem-solving strategies are recommended after systematically sorting out diverse problem models from these patents investigated. Regarding the implementation of TRIZ in educational innovation, the TRIZ innovation principle proposed by Chen et al. [1] who had summarized based on a large number of engineering technology patents is considered rather classic. The team led by Mann [8] directed a long-term survey systematically into how well the TRIZ innovation principle originally adopted in the area of engineering technology performed when it was used in the domain of business and management. On the basis of the initial TRIZ innovation principle, this team had collected and analyzed plenty of linked cases before putting forward in match with the business and management domain of the contradictory parameters, which in this team's firm belief could be used to define issues in that domain. Marsh et al. [9] and their partners probed into the conceptual issues that doctoral students encountered when seeking potential solutions in their learning curve, the first time ever for the contradiction matrix to be used to resolve education-related technical conflicts. They redefined the 31 business functions of the contradiction matrix, perfecting the matrix to be more in line with the developing trend of higher education. More importantly, Marsh et al. [9], together with their partners, connected the 40 innovative principles with the education domain and accordingly proposed another 40 innovative principles exclusive to the education domain. Each of the 40 principles newly proposed has been attached with corresponding explanations and real cases, which is definitely more conducive for other researchers not just in making further comparisons, but in deeply interpreting these 40 innovative principles in the education domain. In consequence, not only has the application sphere of the TRIZ theory been extended, but also vital prerequisites have been provided in the utilization of the TRIZ theory to tackle innovation obstacles in the area of education.

Regarding the application of fuzzy theory adopted in this research, Delphi method, a method of surveying experts' opinions and a group decision-making approach, has been established mainly to obtain the consensus among certain expert group and to acquire the consistent viewpoint towards a specific object. The Delphi method is extremely advantageous not only in collecting varying thoughts but also in taking into account the quality of an expert's independent judgment. It is Dawood et al. [7] who analyzed the fuzzy theory into the Delphi method with the aim of overcoming associative barriers annoyed when applying the traditional Delphi method in terms of the research time, cost, and ignorance of experts' opinions. In this untied approach, the geometric mean is treated as the basis of assessment in selecting group's decision-making to avoid the negative impact caused by extreme values, thus bettering the selecting effect of the assessment factor. The outcome generated via the fuzzy Delphi method is feasible to be input into FMEA for further discussion. FMEA was propounded by reliability engineers in 1950 during the failure analysis of the rocket system. When applied for failure analysis, it is called failure mode effect analysis (FMEA). Despite its superiority in uncomplicated principles and strong operability, there are high possibilities of occurring errors caused by robust personal subjectivity in the rating process of the risk factors such as occurrence (O), severity (S), and detection (D). In view of the defects that related theoretical support could be insufficient in the attempt of equivalently quantifying risks by multiplying O, S, and D to obtain RPN and that risks represented by the same PRN could be indistinguishable, a couple of scholars such as Pillay and Wang [11] and Yan et al. [3] suggested FMEA, which is based on evidence reasoning, and meanwhile simulated the diversity and uncertainty arising from the FMEA evaluating process for rating. This method enables experts in concerned area to evaluate risk factors with the conventional mode of digital rating. In conformity with fuzzy logic, Bowles and Peláez [2] described another way of prioritizing the risks generating in the failure mode in FMEA system, and fuzzy language was used to outline O, S, D, and the failure risk. The relationship between the failure risk and O, S, and D was demonstrated via the "if-then" fuzzy rule base developed out of experts' knowledge and experience. Since the result of risk assessment is illustrated in fuzzy language, accurate values can only be gained and later sorted after the fuzzy language has been defuzzified.

With the research objective of addressing the defects existing in the integrated teaching of theory and practice for the auto chassis major in China, FMEA has been picked in this study as the core framework, along with the application of both fuzzy Delphi and fuzzy inferences stemming from the fuzzy theory. After the key failure modes disclosed in the integrated teaching of theory and practice had been found in related courses for the vehicle chassis major in secondary vocational schools, viable solutions and optimizing tactics were suggested based on TRIZ and how well the effect of optimization presented was verified as well. Concerning the remaining sections of this research, Section 3 introduces the model constructing and solving; Section 4 outlines relevant cases and data analysis; and the summary is delivered in the last section.

3. Research Methodology

3.1. Problem Statement. This research was initiated in January 2020. At its first stage, expert questionnaires of fuzzy Delphi method were issued among 5 experts (a professor of auto repair specialty, 2 senior technicians of auto repair, and 2 senior lecturers from certain school, with the weight allocation of 0.3, 0.3, 0.2, 0.1, and 0.1), of whom the opinions of decision-making group had been anticipated. In this study, the auto repair major of a specific secondary vocational school located in Suzhou City of China was picked and surveyed to confirm the key failure mode's assessment factors lying in the integrated course teaching of theory and practice for auto chassis major. The research outcomes would be elucidated mainly from the following three segments: the first segment expounded on how to construct the fuzzy failure mode and the effect analysis; the second provided certain countermeasures based on TRIZ; and the third verified how these strategies had functioned in this school after half a year.

3.2. Development Process of the Integrated Course of Theory and Practice. According to the Notice on Printing and Distributing Technical Regulations of Developing Integrated Course issued in 2012 by the Ministry of Human Resources and Social Security of China, the concerned development process is mainly composed of the following six parts.

3.2.1. Completion of the Organic Integration of Multiple Courses. Instead of a mere addition of various course contents, the organic integration of distinct courses refers to the intact procedure where the whole knowledge needs to be reorganized and summarized before being finally integrated into pursuit of deeper logicality.

3.2.2. Compilation of Teaching Syllabus, Plans, and Materials Adaptive for Integrated Teaching. In view of the fact that the teaching syllabus and contents adopted in secondary vocational schools are limited solely to the segmented teaching model, it is nearly impossible for these teaching syllabus and contents to perform effectively in the integrated course teaching. Besides, the teaching materials currently used for the integrated teaching of "auto chassis" course are not impeccable yet. To better tackle this issue, it is highly advisable that secondary vocational colleges formulate their own teaching syllabus, respectively, and compile corresponding textbooks. There is no doubt that the teaching outcome would turn out to be fabulous if such type of textbooks came into use, which is compiled in conformity to students' personal learning situation, schools' talent training positioning, and the latest social requirement on students.

3.2.3. Cultivation of Dual-Qualified Teachers. For the aim of cultivating dual-qualified teachers, exclusive training opportunities are exceedingly recommended in secondary vocational schools for educators who are responsible for the integrated teaching of theory and practice in the "auto chassis" course to lift bit by bit their teaching ability in the training process. Meanwhile, ideological work prepared for these teachers could never be ignored for the sake of their perfection in teaching expertise. Furthermore, young teachers are able to visit and learn about a specific enterprise by taking advantage of the school-enterprise cooperation. In this way, this group of teachers would, on one hand, be awarded the wonderful chance of strengthening their individual practical ability and, on the other, gain a more comprehensive understanding of their students' present learning situation, thus playing a satisfying role in comprehending relevant requirements asserted in job descriptions towards potential job hunters. Likewise, it is absolutely facilitating if schools are able to invite professional talents dispatched from enterprises to give certain extracurricular tutoring among the students, or to offer forums at campus to grab students' attention.

3.2.4. Classroom Construction for Integrated Teaching of Theory and Practice. The construction of classrooms prepared for the integrated teaching of theory and practice is, to high extent, no picnic for many schools as these schools are commonly in lack of not just sufficient funds but also suitable precedents to imitate. In view of this embarrassing situation, vocational schools, in quest of support in financial funds and training venues, are advised to strengthen their interaction with the local government to cope with the financial matter and the restricted area. While in the purchase of relevant multimedia equipment, factors such as the cost and practicality of these items must be thoroughly considered; otherwise, the integrated teaching tends to face the adversity of being doomed a failure. In these classrooms prepared for the integrated teaching, specialized training stations, full set of training and measuring tools, and sufficient training equipment are indispensable, so is the teaching model of an intact vehicle.

3.2.5. Reinforcement of Practical Training Management. It is not strange at all that practical training has been ignored unconsciously in numerous schools when conducting the integrated teaching model due to the conventional thinking pattern entrenched solidly in China's education, to which constant and intensive attention needs to be paid in the upcoming implementation of the integrated teaching of theory and practice in the "auto chassis" course. An intact teaching system aimed at schools' practice teaching deserves to be formulated; hereby, each of the teaching staff and every student could be pressured to comply with it. At the same time, scrupulous maintenance of these classrooms reserved for the integrated teaching ought to be strengthened, and any illegal operation must be forbidden during the learning process among all the users, whether it is a student or a trainer; otherwise, it is on the cards that the teaching facilities might be damaged or out of order.

3.2.6. Delegation of the Teaching Assessment System to Students. The teaching assessment system must be delegated to students considering the ubiquitous situation where a mass of teachers tend to think highly of the teaching outcomes they have achieved, but pitifully enough fail to receive satisfactory assessment results in the end, for which lack of related experience in the integrated course teaching of "auto chassis" commonly existing in China should be blamed. On the contrary, once the teaching assessment system is delegated to students, they are enabled to elaborate whatever they think about, including their expectations on teachers' teaching attitude, teaching pattern, and methods.

3.3. Establishment of Assessment Criteria via the Fuzzy Delphi Method for the Integrated Course Teaching of Theory and Practice. Through relevant literature review and several expert interviews, the failure assessment mode of the integrated teaching system of theory and practice in auto chassis has taken its preliminary framework, functioning as the devising basis for the fuzzy Delphi method questionnaire and as the selecting foundation for the assessment criteria to further facilitate the subsequent steps. To block these biases caused by personals' subjective consciousness, the fuzzy Delphi method proposed by Klir and Folger [6] is introduced, of which differing opinions offered within the project team are incorporated by processing the geometric mean as the intermediate value of the triangular fuzzy number. In this way, the key factors tend to be evaluated more in line with the real situation. Saaty [15] asserted that more accurate outcomes could be captured by representing experts' consensus of decision-making with the geometric average in disposing the generalization of averages. In virtue of these scholars' proposals, the geometric mean would be deployed in this research as the intermediate value of the triangular fuzzy number. Prior to defuzzifying the fuzzy set via the fuzzy theory for the sake of a faultless weighted value of fuzzy risk, a fuzzy set is the major premise needed to form concerning the severity, occurrence, and undetectability of each factor originating from the project's team members in the means of fuzzy Delphi method, and subsequently, it comes the judging section, which proceeds according to the following steps:

(1) a_{ij} is set as expert i's opinion towards failure cause j. Firstly, a triangular fuzzy number $A_{ij} = (l_{ij}, m_{ij}, u_{ij})_{L-R}$ is ascertained, which contains all the opinions of expert i towards failure cause j, and among which, $m_{ij} = (a_{1j} \times a_{2j} \times \cdots \times a_{nj})^{1/n}$ and $u_{ij} = \max(a_{1j}, a_{2j}, \ldots, a_{nj})$, $i = 1, \ldots, n$.

(2) The fuzzy relationship matrix W of the entire evaluations from expert i towards failure cause j is established. $W = (w_1, w_2, \ldots, w_j)$.

$$w_j = \left(l_{ij}, m_{ij}, u_{ij}\right)_{L-R}, i = 1, \cdots, n, \quad j = 1, \cdots, r. \tag{1}$$

(3) The fuzzy off-bar matrix obtained is converted into a single value through the method of average.

$$O_j = \frac{\left[\left(u_j - l_j\right) + \left(m_j - l_j\right)\right]}{3} + l_j, \quad j = 1, \cdots, r. \tag{2}$$

(4) Eventually, the evaluation set of the severity and the undetectability of all these failure causes after defuzzifying the fuzzy set via the fuzzy theory are gained, which is followed by the conversion into a crisp value.

3.4. Fuzzy Failure Mode and Effect Analysis (Fuzzy FMEA). Failure mode and effect analysis (FMEA), an analysis technique that identifies the failure mode of a potential product, is universally used for the purpose of detecting failures, which might lead to further accidents or detrimental events. The conduction of FMEA is routinely completed at the early stage of a product's life cycle so that this product's safety and quality can be enhanced and that its risks and costs of development will be weakened, thus ultimately helping lift the corporate image and competitiveness in addition to the customer satisfaction. Typically, FMEA is used roughly for three purposes: design, process, and service, also named DFMEA, PFMEA, and SFMEA separately. The model deployed in this study is SFMEA, namely FMEA for service. At the early planning stage of the service system, the potential missing mode of each process, along with its degree of impact, has been explored before the severity (S), occurrence (O), and detectability (D) of each failure mode are unearthed. Next, diverse workable methods are expected to seek in order to avert or mitigate the occurrence and the negative impact of that service failure mode for the eventual sake of the refinement of the system structure's verification competence. In this way, planning of the system structure could be ameliorated before the service system is officially put into operation, so that the failure mode of service could be neatly avoided and consequently there comes gratifying elevation in the service quality [5].

A detailed analysis of the failure mode has already been delivered in the traditional edition of FMEA, along with a summary of these factors linked with the failure factors. In that traditional edition, risk priority number (RPN) has been adopted to measure the three key parameters, including severity (S), difficulty of detecting (D), and occurrence (O), on a scale of 1 to 10 points, and lastly, the risk priority number can be figured out by multiplying these three parameters. Undeniably, there may be subjective bias of opinions during the assessing process where the entire qualitative opinions are appraised in a quantitative way. Regarding each project with a higher risk priority number, the optimization measures recommended shall be taken first to fence the system against any risks. To overcome these shortcomings, the steps of constructing the fuzzy risk priority number (FRPN) model [11] adopted in this study are outlined as follows:

(1) The semantic variables and the membership function of fuzzy risk are constructed: firstly the entire measuring criteria of occurrence and difficulty of detecting and severity set in the FMEA table are combined, and a fuzzy set diagram of fuzzy risk is drawn. Every variable is feasible to be described through verbal ratings: {*FL* (fairly low), *L* (low), *M* (medium), *H* (high), *FH* (fairly high)}. In reference to the definition of FMEA commonly used in the service industry [10], a relational diagram between verbal ratings and membership functions has been offered, with the rating standards of these verbal ratings interpreted at length in Table 1 (Figure 1).

(2) Assume that a total of n experts judge whether a specific failure mode "$x \in A$" is "true" or "false," in which $x \in X$, and A refers to the fuzzy set of X. $a_i(x)$ is used to represent the judgment of expert $i (i = 1, \ldots, n)$ on this failure mode: when $a_i(x) = 1$, it means that expert i judges this failure mode to be true, while $a_i(x) = 0$, it signifies that expert i estimates that mode to be false. When $A(x) = 1$, $x \in A$; $A(x) = 0$, then $x \notin A$, but if $A(x) \in (0, 1)$, x is

Table 1: Verbal rating interpretation of each linguistic variable.

Verbal rating	Linguistic variable O	Linguistic variable S	Linguistic variable D	Triangular fuzzy value
VL (very low)	Extremely rare occurrence of failure mode	The teachers are willing to adopt the integrated teaching of theory and practice with a normal teaching model despite this factor	Almost definitely could this factor be spotted prior to the teaching arrangement	(0, 0.15, 0.3)
L (low)	Possibly once, but no more again	The teachers are still willing to adopt the integrated teaching of theory and practice but with some resistance penetrated in teaching due to this factor	Highly likely would this factor be spotted prior to the teaching arrangement	(0.2, 0.35, 0.5)
M (medium)	Possible for once more	The teachers are not averse to the integrated teaching of theory, but restricted by this factor, smooth teaching cannot be guaranteed	Half as likely could this factor be spotted prior to the teaching arrangement	(0.4, 0.6, 0.8)
H (high)	Basically at least once	Part of the teachers are averse to the integrated teaching of theory due to this factor and unwilling to adopt it in class	Rarely could this factor be spotted prior to the teaching arrangement	(0.7, 0.85, 1.0)
VH (very high)	Basically several times of occurrence	The majority of the teachers are allergic to the integrated teaching of theory due to this factor and unwilling to adopt it in class	Almost possible could this factor be spotted prior to the teaching arrangement	(0.9, 1.0, 1.0)

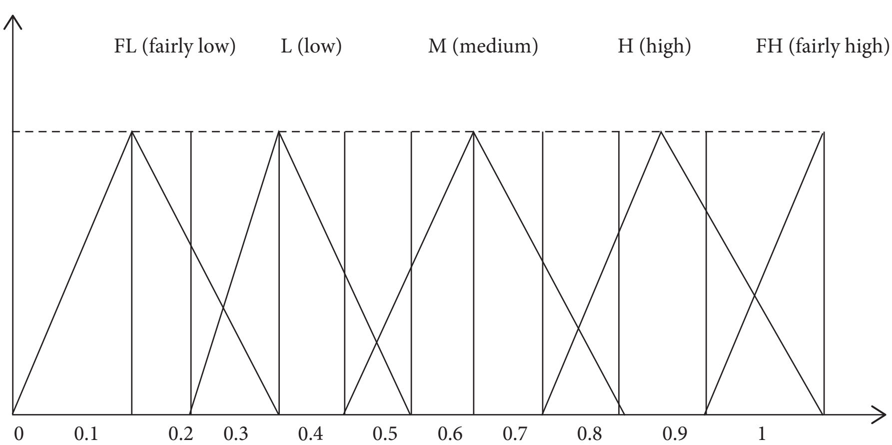

Figure 1: Membership function of verbal ratings.

deemed as part of A. When an expert shows any variance in his/her personal domain knowledge and professional experience, $A(x) = \sum_{i=1}^{n} C_i a_i(x)$ will be regarded as the membership function of element x towards the set A. C_i indicates the weight value assigned according to the domain and experience of expert i, and right here, $\sum_{i=1}^{n} C_i = 1$.

(3) A semantic rule base is established: the grammatical form "if-then" is most widely adopted in the methods and procedures of establishing a rule base, namely a genre of rule based on which an expert's knowledge is rewritten using the "if-then" form after having garnered his/her knowledge and the operator's working experience. With the aim of building a fuzzy rule base, experts need to classify various assemblies of verbal ratings regarding the linguistic variables O, S, and D and later depict them through an assembly of verbal ratings with risk priority, thereby reflecting the risk priority of each rating assembly of O, S, and D, respectively. A total of 5 verbal ratings are set up for each linguistic variable of O, S, and D, so there are 125 ($5 * 5 * 5 = 125$) assemblies of verbal ratings in sum; that is, the total number of fuzzy inference rules is 125. Considering the fact that there are a couple of verbal rating assemblies sharing the same risk priority among those 125 rules acquired, repeated trials and reductions are needed to eventually obtain the functional fuzzy rule base.

(4) The fuzzy theory is examined: as for the input of the fuzzy logic inference, it can be either an explicit value or a fuzzy set, while the output must be a fuzzy set. In this way, a conclusion's degree of membership should be set as "degree of truth," followed by ranking each risk priority number and every failure mode, and finally defuzzifying these values in order for an explicit outcome. Supposing that n sorts of verbal rating assemblies are attained in pursuit of verbal ratings of risk priority in the process of integrating the verbal rating assemblies of each failure

Table 2: 40 inventive principles for education (Marsh et al. [9]).

(1) Segmentation	(2) Taking out (extraction)	(3) Local quality	(4) Asymmetry	(5) Merging (combining)
(6) Universality	(7) Nested doll (matryoshka)	(8) Anti-weight (counterweight)	(9) Preliminary anti-action	(10) Preliminary action
(11) Beforehand cushioning	(12) Equipotentiality	(13) Inversion	(14) Curvature	(15) Dynamics
(16) Partial or excessive actions	(17) Another dimension	(18) Mechanical vibration	(19) Periodic action	(20) Continuity of useful action
(21) Rushing through	(22) Blessing in disguise	(23) Feedback	(24) Intermediary	(25) Self-service
(26) Copying	(27) Cheap short-living objects	(28) Mechanics substitution	(29) Intangibility	(30) Flexible shells and thin films
(31) Porous materials	(32) Color changes	(33) Homogeneity	(34) Discarding and recovering	(35) Parameter changes
(36) Phase transitions	(37) Thermal expansion	(38) Strong oxidants	(39) Inert atmosphere	(40) Composite materials

mode O, S, and D, the explicit value of these n sorts of verbal ratings are $A_1, A_2, \ldots, A_n$, respectively, when the membership value is 1, and the weights assigned to each rating above are $\omega_1, \omega_2, \ldots, \omega_n$ apiece, and finally, the defuzzification value Z_j of the failure mode j calculated through the method of maximum weighted mean turns to be

$$Z_j = \frac{\left(\sum_{i=1}^{n} \omega_i \times A_i\right)}{\sum_{i=1}^{n} \omega_i}. \quad (3)$$

3.5. Theory of Inventive Problem-Solving (TRIZ). To go a step further, Marsh et al. [9] incorporated 40 inventive principles with the educational domain and put forward another 40 inventive principles targeted specially for latter, with each principle supported by corresponding explanations and cases. As their method is more conducive to our further cross-reference, deeper understanding of how these 40 principles are interpreted in the educational domain can be ensured, thus forging the requisite for the elimination of innovation issues residing in the educational domain in the means of TRIZ. There is a sum of 40 inventive principles for education, as shown in Table 2.

Modeling after the classic TRIZ, Mann [8] brought up the technical contradictory parameters aimed at the field of engineering technology, along with 31 parameters applied in the area of business management. When bringing forward the management parameters formulated for education innovation, we have, in connection with the actual situation of education innovation, referred to these business management parameters proposed by Mann [8] as the blueprint and eventually succeeded in redefining the 31 management parameters produced, especially for education innovation in accordance with the sequential process of research and development, production, supply, and support for educational outputs. These 31 management parameters are primarily classified into two parts, with one part used to illustrate the process of providing educational services, namely R&D-production-supply-support, each of which is defined based on the five fundamental characteristics: capability, cost, time, risk, and interface. Table 3 demonstrates with concreteness the entire management parameters. In respect of how to seek the principles of innovation, two approaches are the most striking: one is to draw on the correlation chart between the parameters and the principles of innovation discovered by Mann [8] through a large number of case studies in the field of business management (refer to Mann [8] for details); another is to apply the contradiction matrix in which those principles of innovation frequently used in perfecting every management parameter have been summarized in the correlation chart between the parameters and the principles of innovation.

All the inventive principles are effectively linked with management parameters (refer to Mann [8] for details). A total of 31 management parameters could formulate a 31×31 contradiction matrix, of which each parameter is likely to connect with the rest 30 parameters to regenerate a parameter pair of contradiction. Since the targeted principle of innovation involved in each parameter pair has been expounded in that parameter pair of contradiction, all the specific principles of innovations could at bottom be disclosed in the process of modal analysis if we attempt to connect the parameters and the contradiction matrix involved in the case studies of Section 4 with corresponding inventive principle set.

4. Results

4.1. Fuzzy Failure Mode and Effect Analysis (Fuzzy FMEA). Table 4 presents the failure mode of the teaching system selected through Delphi method. After each of the five experts had fulfilled the fuzzy FMEA questionnaire, we adopted the rule base of 35 fuzzy inferences, which was previously curtailed by Pillay and Wang [11], and later, we discovered the fuzzy rule base with the corresponding risk to rate their risk priority. Finally, we employed both the experts' weight allocation and formula (3) in defuzzifying each risk priority. When the membership function of verbal rating amounted to 1, the explicit values of all the verbal ratings depicting the risk priority were as follows: L (low) = 0.055, FL (fairly low) = 0.461, M (moderate) = 0.911, FH (fairly high) = 2.041, and H (high) = 7.111, as manifested in Table 5. As an interpretation of Table 5, the higher the defuzzification value, the greater the risk priority, equivalently, the greater the risk. It could be remarked from the table that the failure mode with the highest priority revealed

Table 3: 31 management parameters of educational innovation.

(1) R&D capacity	(6) Production capacity	(11) Supply means	(16) Support capability	(21) User needs	(26) Convenience	(31) Stability
(2) R&D cost	(7) Production cost	(12) Supply coast	(17) Support cost	(22) Information volume	(27) Adaptability/functionality	
(3) R&D time	(8) Production time	(13) Supply time	(18) Support time	(23) Information flow	(28) System complexity	
(4) R&D risk	(9) Production risk	(14) Supply risk	(19) Support risk	(24) Exogenous harmful factors	(29) Control complexity	
(5) R&D interface	(10) Production interface	(15) Supply interface	(20) Support interface	(25) Endogenous harmful factors	(30) Competitive pressure	

Table 4: Failure mode of the integrated teaching system of theory and practice.

No.	Failure mode	Failure effect	Failure cause
1	Unsatisfying teaching outcomes	Students' unintentional learning	(1) Insufficient training equipment (FM1) (2) Inadequate space (FM2) (3) Irrational matching between teachers and students (FM3) (4) Teachers' unsatisfactory professional level (FM4) (5) Loud noise in the workshop and lack of sound insulation between workstations (FM5) (6) Students' low comprehensive literacy (FM6) (7) Students' poor foundation in relevant theoretical knowledge (FM7) (8) Unreasonable duration arrangement for both general knowledge class and training class (FM8)
2	Security incidents	Mortal dangers to students and property loss of the school	(1) Students' uncertainty in operations caused by their intensive curiosity (FM9) (2) School's insufficient error-proofing equipment for training (FM10) (3) Students' poor security awareness (FM11) (4) Illegal operation on the lifting machine (FM12) (5) Jack lever's being rotated casually by students (FM13)
3	Teachers' aversion to the integrated teaching of theory and practice	School's inadequate promotion of the integrated teaching of theory and practice	(1) Few genuine dual-qualified teachers (FM14) (2) Trivial preparation for the integrated teaching of theory and practice (FM15) (3) Indifference from school leaders (FM16) (4) Illogical classroom planning for the integrated teaching of theory and practice (FM17)
4	School education's failure in connecting with enterprise production	Employment difficulties (retraining from enterprises regardless of success in getting employed)	(1) Students' aversion to dirty and exhausting tasks and their failure in preserving (FM18) (2) School's underdeveloped training equipment (FM19) (3) Untimely update on teaching contents for auto repair major (FM20) (4) School's failure in keeping up with the developing pace of correlated industry (FM21)

the fact that students were poor in their safety awareness, with a defuzzification value of 5.353, while the mode with the lowest risk priority indicated that the teaching content of the auto repair major failed to get updated in time, with the defuzzification value reaching 0.055.

Risk priority, the key indicator used for failure analysis of a specific teaching system, is a comprehensive evaluation indicator of the potential risk index and the hazard rating of a certain failure element. Based on the defuzzification value Z_j of risk priority, all the obsolescent items involved in teaching activities were ranked according to their degree of optimizing demand from large to small, and the one with the largest value was counted as the service item, which should be improved in the first priority. Among these 21 obsolescent items involved, "students' poor security awareness," "students' uncertainty in operations caused by their intensive

Table 5: Risk priority ranking based on fuzzy rule base.

Failure mode	O	S	D	Risk priority	Z_j	Risk priority ranking
FM1	*VL*	*H*	*L*	0.58*L*, 0.68*FL*	0.274	11
FM2	*L*	*VL*	*L*	*L*, 0.16*FL*	0.111	18
FM3	*VL*	*L*	*L*	*L*, 0.16*FL*	0.111	18
FM4	*M*	*H*	*M*	0.4*M*, 0.66*FH*	1.614	3
FM5	*L*	*L*	*L*	0.86*L*, 0.78*FL*	0.248	15
FM6	*VL*	*H*	*L*	0.58*L*, 0.68*FL*	0.274	11
FM7	*VL*	*M*	*M*	0.5*L*, 0.92*FL*	0.318	10
FM8	*VL*	*H*	*M*	0.86*L*, 0.14*FL*	0.112	16
FM9	*H*	*H*	*M*	0.88*FH*, 0.62*H*	4.136	2
FM10	*H*	*L*	*M*	0.66*M*, 0.94*FH*	1.575	4
FM11	*H*	*H*	*H*	0.52*FH*, 0.98*H*	5.353	1
FM12	*VL*	*H*	*L*	0.58*L*, 0.68*FL*	0.274	11
FM13	*M*	*L*	*L*	0.4*FL*, 0.58*M*	0.727	8
FM14	*H*	*L*	*M*	0.66*M*, 0.94*FH*	1.575	4
FM15	*VL*	*H*	*M*	0.86*L*, 0.14*FL*	0.112	16
FM16	*L*	*M*	*L*	0.4*FL*, 0.58*M*	0.727	8
FM17	*L*	*VL*	*L*	*L*, 0.16*FL*	0.111	18
FM18	*H*	*L*	*M*	0.66*M*, 0.94*FH*	1.575	4
FM19	*VL*	*H*	*L*	0.58*L*, 0.68*FL*	0.274	11
FM20	*VL*	*L*	*VL*	*L*	0.055	21
FM21	*L*	*H*	*M*	0.66*M*, 0.94*FH*	1.575	4

curiosity," and "teachers' unsatisfactory professional level" ascended the top three in the risk assessment ranking, followed in sequence by "school's insufficient error-proofing equipment for training," "few genuine dual-qualified teachers," "students' aversion to dirty and exhausting tasks and their failure in preserving," and "school's failure in keeping up with the developing pace of correlated industry." In subsequent part of this study, these seven items would be probed into as well, along with recommendations for optimization by virtue of TRIZ.

4.2. Optimization of Obsolescent Items Involved in Teaching Activities via TRIZ. FMEA, a sort of method that makes it accessible to plainly point out those obsolescent items needed to be optimized in teaching activities, turns eclipsed in terms of offering effective solutions to problems; thus, other tools are still indispensable. TRIZ, a theory that is both abundant in innovative ideas and powerful in problem-solving, is able to can make up for the deficiencies of FMEA. By applying the TRIZ contradiction matrix, all the technical parameters of these obsolescent items involved in teaching activities would be recapitulated first, and next each obsolescent item would be matched with a corresponding TRIZ parameter wholly in consonance with the matching relation to construct a contradiction matrix. Afterwards, those appropriate inventive principles and methods would be screened out according to the contradiction revealed between the deteriorated and optimized parameters in that matrix.

The essence of TRIZ lies in its astonishing efficiency of faultlessly disposing the failures existing in teaching activities while imposing no harm on these teaching activities. In light of this advantage, either the innovation principles were unearthed in this research according to TRIZ parameters corresponding to related teaching failures exhibited in Mann [8], or the failure parameters involved in teaching activities were brought into the contradiction matrix for further analysis under the guidance of corresponding principles. Whichever approach had been adopted, the ultimate goal was to promote the teaching quality by formulating targeted optimization measures, which could be applied in successfully eliminating the failures remaining in teaching activities and subsequently lowering the failure risk of teaching activities. Despite several repeated TRIZ inventive principles in the contradiction matrix, each optimization measure varies depending on the failure mode. In the analysis of the FMEA model, a couple of optimization measures were released in conformity with the seven obsolescent teaching items in this study based on the TRIZ principles. Concerning the rest teaching failures, the principles employed in purging them maintained the same, with the defuzzification value interpreted according to the risk priority number as follows.

4.2.1. Failure Modes 11, 9, and 18: "Students' Poor Security Awareness," "Students' Uncertainty in Operations Caused by Their Intensive Curiosity," and "Students' Aversion to Dirty and Exhausting Tasks and Their Failure in Preserving". Currently, schools are unsurprisingly confronting a series of thorny problems about talent cultivation pervading at the primary education stage, such as students' lack of not just professional interest, but practical ability and innovative spirit, and primary education's disengagement with higher education. These phenomena of "students' poor security awareness," "students' uncertainty in operations caused by their intensive curiosity," and "students' aversion to dirty and exhausting tasks and their failure in preserving" selected from the failure modes are none other than the most vivid reflections towards those problems. As "reliability" existing among the parameters is interpreted into "reactions that a system, an organization or an individual has produced towards changes from the outside," it is rational to claim that this model embodies the parameter of "reliability." Accordingly, we are permitted to extract these inventive principles of 15, 17, 23, and 40 related to the parameter of improving reliability according to Mann [8], with details explained as follows.

First and foremost, the measurement of "pedagogy discussion among teachers coming from different or similar disciplines" embodies the 15th inventive principle "dynamics" and the 40th principle "composite materials." With regard to dynamics, its third dimension refers to "to make movable or reliable a system or process which is originally rigid or inflexible." Through this measurement, the originally rigid form of a team within which only the teachers belonging to the same discipline are allowed to exchange and discuss has successfully been upgraded into a cross-communicating form suitable for multiple disciplines, thus rewarding teachers with the chance of both acquiring multidisciplinary knowledge and fostering their own ability of adapting their educational contents in line with the social needs. When it comes to the principle of composite materials, it is deemed as a process where a system or organization shifts from the original single structure to a composite (diversified) structure, or a conjunction of which multiple skills or abilities are consciously applied. The practice of "pedagogy discussion among teachers coming from different or similar disciplines" facilitates the teacher team system's transitioning from an isolated mode where teachers responsible for a specific discipline focus merely on that subject to a multi-composite structure where cross-explorations are accessible among diverse disciplines. By such practice, teachers stay conscious in giving full play to their personal competencies in that discipline and are allowed to effectively link their own subject with the contents of the rest ones, thus continuously promoting the comprehensive ability of the entire teacher team. This has ideally reflected the composite materials of the 40th inventive principle.

In the second place, the measurement of "pedagogy discussion among teachers coming from different or similar disciplines" above reflects in like manner the fourth meaning of the 17th inventive principle "another dimension," which means "to place an event on one side by tilting or relocating it." By the practice of "pedagogy discussion among teachers coming from different or similar disciplines," the vertical teacher team of a single discipline needs to be tilted and transformed into a horizontal exchanging team composed of diverse disciplines, thus symbolizing the 17th inventive principle.

Thirdly, the practice of "reflection" from students reveals the first meaning of the 23rd inventive principle, namely "to optimize a process or an action by bringing in feedback (backtracking or cross-checking)." Students' "reflection" is performed in a self-criticism form for the perfection of their own thinking and behaving, undoubtedly embodying the inventive principle "feedback."

4.2.2. Failure Mode 4: Teachers' Unsatisfactory Professional Level. In allusion to the self-enclosed pattern currently prevailing in schools, together with their worrying notion that teachers are attached to them, reforms are in dire need not only in which direction schools are marching forward but in how to train teachers. By bridging between this failure mode and the set of contradictory parameters, namely system complexity and stability, we discovered that the worsen the parameter of system complexity ran, in other words, the more complex the development direction and the method of training teachers in schools trended, and the better the stability would evolve, which was reflected by the overall stable development of schools within a county. Otherwise, the stability would deteriorate (remain unchanged or decline). This discovery is absolutely a persuasive demonstration of the contradiction between the two parameters: system complexity and stability. Accordingly, we are eligible to pick out these inventive principles of 15, 17, and 26 involved according to the contradiction matrix (Mann [8]), with details depicted as follows.

First of all, the resolution of "dismantling schools' self-enclosed pattern and promoting interactions among each other based on schools' partnership developing" manifests the third dimension of the 15th inventive principle "dynamics," which is "to make movable or reliable a system or process which is originally rigid or inflexible." This dimension works ideally in concert with the cooperative education program among higher vocational colleges as the latter attempts to transform the original inflexible "self-enclosed pattern" into a mobile and adaptable school-running one, which is marked by "mutual interaction with other schools."

Next, both the 17th inventive principle "another dimension" and the 26th one "copying" are precipitated in the endeavor of "eradicating the conventional pattern that teachers remain still where they are working for and meanwhile arranging remote exchanges or regional dispatches with the core goal of facilitating communications amongst teachers from different schools." The measure of teachers' "remote exchanges or regional dispatches" is counted as a type of transformation for training teachers from the initial unitary mode that "teachers remain still where they are working for" into a two-dimensional or three-dimensional training model, which involves "remote exchanges or regional dispatches," thereby precipitating the inventive principle "another dimension." Regarding the principle "copying" whose first dimension lies in "referring to successful experience from another system or another part of certain system," it is favorably reflected in the initiative where teachers interact with each other or are dispatched to other regional schools as they are by the same token learning or referring to the successful experience from other teachers or teams.

4.2.3. Failure Mode 10: School's Insufficient Error-Proofing Equipment for Training. The auto technology specialty of each school, in the face of neither a single enterprise nor enterprises of the same category, is required to take into account the job assignments from various enterprises instead when setting up training devices or error-proofing equipment. All these assignments ought to be analyzed, aggregated, and summarized attentively so that contents that share general similarities could be sorted out for further teaching. At the mention of teaching contents, they are anticipated to be utilized in facilitating students' extensive acquisition of both professional knowledge and skills, ranging from getting familiar with the equipment, selecting the equipment, wiring, programming, to debugging and operating, in order for the design and completion of a project. In the process of setting up training devices or error-proofing equipment, project-based teaching is bound to receive effective acceleration in its implementation, execution, and promotion.

The essence of all the conflicts above resides in whether the quality and quantity of courses offered in schools are able to meet the requirements raised by each party. With added equipment, devices, or time provided, every conflict would be swept away thoroughly. Nevertheless, the school system is well-defined without any significant modifications. In this sense, further generalization could be executed based on TRIZ since it is workable to transform both the quality and quantity of training devices or error-proofing equipment into the parameter "volume of information (data)," and the school system into the parameter "waste of time." In such manner, the conflict above could be converted into a contradiction between the parameter "volume of information (data)" and the parameter "waste of time." Hereby, we are qualified to pick out these inventive principles of 2, 13, and 17 involved according to the contradiction matrix (Mann [8]), with details manifested as follows:

Inventive Principle 2: Taking Out (Extraction). This inventive principle means either to extract the negative parts or attributes from an object, or to extract only the essential parts or attributes from it. In accordance with this principle, two measurements are exceptionally recommended. For one thing, students need to be divided and distributed into separate majors with differing cultivating orientations after they have got enrolled at school, to guarantee the seamless connection with diverse selective demands from enterprises. For the other, job assignments from enterprises ought to be summed up before both the typical assignments and the error-proofing knowledge are extracted. By converting these typical assignments and the error-proofing knowledge into students' learning tasks, which will further be split up for teaching in different areas, the teaching content of specialized courses is empowered to better reflect the basic skills, error-proofing knowledge, and professional quality mandatory for corporate production.

Inventive Principle 13: The Other Way Round. The central meanings of this principle are as follows: the first is to invert the action(s) used to solve the problem; the second is to make movable parts or the external environment fixed and fixed parts movable; the third is to turn the object or process "upside-down" or "inside-out." Based on this principle, a couple of countermeasures for optimization are offered, involving to switch the teaching method and create realistic situations, to teach with the task-oriented method, to strengthen students' ability in logical thinking and problem-solving, and to block occupational security incidents caused by mistakes.

Inventive Principle 17: Another Dimension. This principle is illuminated in these ways: to move an object in two- or three-dimensional space; to use a multi-story arrangement of objects instead of a single-story arrangement; to tilt or reorient the object, laying it on one of its sides; and to use "another side" of a given area. The strategy derived from this principle is to impart to students knowledge in regard to safety protection and innovation and entrepreneurship in addition to those vocational courses, so that satisfactory achievements could be reaped not only in expanding students' employment space but also in boosting students' sustainable development.

4.2.4. Failure Mode 14: Few Genuine Dual-Qualified Teachers. Being exposed to the prevailing lack of "high-quality skilled talents" caused by the social separation among production, education, and research, corresponding countermeasures are in dire need to accelerate the development of skilled personnel by fortifying cooperation between universities and enterprises. In the analysis, we attempted to link this failure mode with the two contradictory parameters of supply means and adaptability, and thereby discovered that when the parameter of supply means deteriorates, in other words, the talent training mode grows complicated, and the parameter of adaptability will consequently ameliorate, which is reflected in the capability of being able to react to various existing challenges; otherwise, the parameter of adaptability will deteriorate (stay unchanged or fall). This relationship successfully reveals the contradiction between the two parameters of supply means and adaptability. In this sense, we are entitled to pick out these inventive principles of 7, 13, 15, 17, and 19 involved according to the contradiction matrix (Mann [8]), with details given as follows.

As for the first initiative above all, schools are suggested to interconnect intensely with enterprises, industries, and industrial parks for the ultimate accomplishment of point-line-surface cooperation, embodying the 5th innovative principle "merging" and the 15th principle "dynamics." The first implication of "merging," that is, "to bring closer together (or merge) identical or similar objects, assemble identical or similar parts to perform parallel operations," is properly illuminated by the aggregation of schools' teaching functions when enterprises, industries, and industrial parks interconnect spatially with campuses. In terms of the principle "dynamics," whose third meaning is "to make an object (or process) movable or adaptive if it is rigid or inflexible," it can be rationally mirrored since the precise reason why schools collaborate with enterprises is that they desire to cultivate skilled talents who are adaptable enough by reforming the original teaching pattern that used to be rigid and inflexible in a written form.

Next, the move of "perfecting the education and training service system and carrying out social training" visualizes the first meaning of the 17th inventive principle "another dimension": "to move an object in two- or three-dimensional space." To be more specific, the original school training was carried out merely at campus, while the reformed training mode is largely extended to multiple dimensions, which involve both enterprises and even the entire society.

Last but not least, schools are greatly advised to "participate in constructing a technological innovation system in which not only enterprises act as the main body and the market is looked up as the orientation, but production, education, and research are jointly connected, and meanwhile launch scientific research services of various disciplines." Such movement manifests the first denotation of the 7th inventive principle "nested doll": "to place one object inside another; place each object, in turn, inside the other." To put it more vividly, the objective of this movement is precisely to place sequentially enterprises and the market inside the construction of that technological innovation system where production, education, and research are jointly connected.

4.2.5. Failure Mode 21: School's Failure in Keeping Up with the Developing Pace of Correlated Industry. Same as the analyzing method in Section 4.2.3, we are definitely qualified to single out these inventive principles of 2, 3, 7, 13, 17, 19, and 28 involved according to the contradiction matrix (Mann [8]), with specific explanations offered as follows.

The inventive principles of 28, 2, and 7 are rather applicable with regard to the cultivation goals of technical professionals in vehicle. Hereby, schools are supposed through specific investigations to probe into optimal talent cultivating programs and related curriculum with enterprises' joint efforts, so that students could be trained in differentiated directions. Besides, brotherly collaboration between schools and enterprises is vital in setting up labeled or predetermined class in response to several companies' individual demands. In reference to the inventive principles of 13 and 28, schools are suggested to strengthen their construction of practical training in which teachers will be allowed to instruct students as if they were exposed to the real-life situation. Additionally, practical training classrooms jointly launched by both schools and enterprises are indispensable for the publicity of corporate culture, thus permitting students an advanced understanding of a company. Under the 7th inventive principle, the collaboration between the two parties needs to be consolidated by dispatching teachers to a specific company as interns to enhance their practical ability. Likewise, technical backbones from enterprises are highly recommended to be invited for campus lecturing. Through all these measures mentioned above, students are rendered great chances of not only getting familiar with the developing trend of both industries and enterprises when still at campus, but mastering essential knowledge and skills needed, so that they are highly likely to familiarize themselves with the future position the moment they begin their career.

From the perspective of teaching mode, specialized courses need to be designed in accordance with the integrated form of theory and practice when the inventive principles of 2 and 7 are referred to. In this manner, an ideal integration of teaching, learning, and practicing would be achieved through the pathway of "learning by teaching and practicing by learning." Teachers are expected to conduct their classes with the task-oriented or project-directed approach as frequently as possible. Through the application of typical job assignments and the creation of authentic situations, not only will the teaching contents prove more functional, but also students are prone to appreciate what they have acquired, finally contributing to enterprises' recognition of those students' professional competence.

In respect of the course content, it is desperately recommended based on the 2nd and 3rd inventive principles that the courses of both auto mechanics and auto maintenance service should be added to the professional basic curriculum. As for the professional core curriculum, supplementary courses in need would contain introduction to new-energy vehicles, principles and technology of auto electronic control, chassis technology and maintenance of new-energy vehicles, driving motor and control technology, power electronic technology of new-energy vehicles, management and maintenance technology of traction battery, comprehensive performance inspection of new-energy vehicles, and fault diagnosis of new-energy vehicles. Concerning the professional extension one, additional courses such as auto insurance and claims, appraisal and evaluation of used cars, and customer relationship management ought to be taken into consideration.

As seen from the arranging sequence of courses, the course of introduction to new-energy vehicles is supposed based on the 3rd inventive principle to be given priority, followed in order by the course of principles and technology of auto electronic control, chassis technology, and maintenance of new-energy vehicles, as well as driving motor and control technology. Afterwards, the course of power electronic technology of new-energy vehicles, along with the course of management and maintenance technology of traction battery, ought to be scheduled prior to comprehensive performance inspection of new-energy vehicles and fault diagnosis of new-energy vehicles. After having completed all the courses above, students are required in line with the talent cultivating program to be dispatched into separate enterprises for internship so that they would get familiar with the company's manufacturing process and post-settings.

In the matter of students' sustainable development, schools are advised based on the 19th inventive principle to continue adding the course of secondary vocational students' cultural accomplishment, as well as the course of speech and eloquence prior to the following ones: practical writing, etiquette for public relations, auto insurance and claims, appraisal and evaluation of used cars, and customer relationship management. By the means of offering extended courses, not only will students' horizons be widely enriched, but their professional qualities tend to be lifted as well.

On the subject of innovation and entrepreneurship, setting up the course of career planning is inevitable of enormous value, so are the course of entrepreneurship education and the course of employment guidance. By offering the course of career planning, students are far more likely to figure out what kind of goals they are supposed to set rationally for the future and what aspects they need to accumulate precisely. For the arrangement of the latter two courses, however, the primary objective is to respond positively to China's call for the entrepreneurship and innovation among the general public and to help equip students with a solid foundation for both learning and entrepreneurship.

4.3. Validity Verification of Teaching Activities Optimized via TRIZ. After the semi-annual implementation of 6 teaching activities proposed according to these optimizing strategies of FM4, FM9, FM10, FM11, FM14, FM18, and FM21 based on TRIZ in the targeted school chosen as our case study, we continued to conduct another survey among the 5 experts previously mentioned, employing the fuzzy FMEA questionnaire on 21 ineffective teaching activities, with the final result illustrated in Table 6. By the paired-samples t-test (shown in Table 7), we noticed that the average value Z_j

Table 6: Ranking of risk priority based on the fuzzy rule base (posttest).

Failure mode	O	S	D	Risk priority number	Z_j
FM1	*VL*	*H*	*L*	0.58*L*, 0.68*FL*	0.274
FM2	*L*	*VL*	*L*	*L*, 0.16*FL*	0.111
FM3	*VL*	*L*	*L*	*L*, 0.16*FL*	0.111
FM4	*L*	*M*	*L*	0.4*FL*, 0.58*M*	0.727
FM5	*L*	*L*	*L*	0.86*L*, 0.78*FL*	0.248
FM6	*VL*	*H*	*L*	0.58*L*, 0.68*FL*	0.274
FM7	*VL*	*M*	*M*	0.5*L*, 0.92*FL*	0.318
FM8	*VL*	*H*	*M*	0.86*L*, 0.14*FL*	0.112
FM9	*M*	*M*	*M*	0.92*M*, 0.84*FH*	1.450
FM10	*M*	*L*	*M*	0.94*FL*, 0.46*M*	0.336
FM11	*M*	*L*	*L*	0.4*FL*, 0.58*M*	0.727
FM12	*VL*	*H*	*L*	0.58*L*, 0.68*FL*	0.274
FM13	*M*	*L*	*L*	0.4*FL*, 0.58*M*	0.727
FM14	*L*	*L*	*L*	0.86*L*, 0.78*FL*	0.248
FM15	*VL*	*H*	*M*	0.86*L*, 0.14*FL*	0.112
FM16	*L*	*M*	*L*	0.4*FL*, 0.58*M*	0.727
FM17	*L*	*VL*	*L*	*L*, 0.16*FL*	0.111
FM18	*L*	*L*	*M*	0.4*FL*, 0.58*M*	0.562
FM19	*VL*	*H*	*L*	0.58*L*, 0.68*FL*	0.274
FM20	*VL*	*L*	*VL*	*L*	0.055
FM21	*L*	*M*	*L*	0.4*FL*, 0.58*M*	0.727

Table 7: Paired-samples t-tests for the difference in mean perceptions between formal test and posttest in Z_j ($N = 21$).

	Paired differences					df	t	Sig. (2-tailed)
	Mean	Std. deviation	Std. error mean	95% confidence interval of the difference				
				Lower	Upper			
Posttest—formal test	0.60124	1.15869	0.25285	0.07381	1.12867	20	2.378	0.027

dropped significantly, which undoubtedly proved the distinct optimizing effect of TRIZ on the school's teaching activities within half a year.

5. Discussion

By selecting the auto repair specialty of some secondary vocational school in Suzhou City of China as the research objective, the researcher has collected and subsequently analyzed all the failure factors existing in each teaching activity by dint of failure mode and effect analysis (FMEA). Based on the exploration of each index's failure risk, optimizing plans have been formulated according to the ranking of each failure factor's risk priority number, during which TRIZ was referred to. In the light of several experts' suggestions and TRIZ inventive principles, a contradiction matrix was formed before eventually laying down for schools' reference these efficient improvement measures targeted at the top seven service failure projects. During the previous course teaching of auto chassis maintenance, teachers got used to imparting pure theoretical knowledge, most of which proved relatively boring and outmoded. Nevertheless, regarding the course of auto electronics technology itself, whose ultimate goal is to cultivate comprehensive-quality talents with both high practical ability and proficient skills, the purely theoretical teaching contents currently adopted have obviously deviated from the original teaching objective intended. Hereby, the unceasing application of modern teaching contents contained in TRIZ is definitely of vital significance to schools by vigorously citing as many real-life cases as possible at class to enhance the previous teaching contents that used to be highly out of times. Considering the high-degree operability of the auto chassis maintenance course, it would be far from enough to effectively promise students' complete grasp of relevant course principles and theories merely by the book-based teaching of theories alone. In this aspect, extra practical operating courses are rather compulsory when schools are dealing with the course setting. Only by putting what has been learned theoretically at class into practical operating are students more likely to gain a deeper understanding and a more flexible grasp of the knowledge obtained in class. Hence, constant innovations based on TRIZ can never be neglected when teachers attempt to ingeniously combine what students are interested in with the theories imparted in class. In practice training, students could be divided into study groups in which they will be granted the great opportunity of sublimating their study by applying what they have mastered from books to practical operating. Moreover, enhanced interactions with students are of similar prominence in the classroom where teachers ought to allow their students to think proactively and independently to put forward wise and innovative solutions. It has been verified in this study that both FMEA and inventive principles of TRIZ are proved to be ideal functional tools for the curriculum construction of auto technology specialty. By means of resource integrating and curriculum optimizing, not only are enterprises' demand for human resource and schools' teaching conditions taken into consideration, but incessant enhancement in teachers' qualification and sustainable cultivation of students are also spotlighted. At the same time, organic bond between schools and enterprises could be attained through these optimizing measures without a hitch, and all parties' enthusiasm would be effectively mobilized to participate in this mission, thus achieving the ultimate coordinated development and all win of each party.

6. Conclusion

Despite these relatively appreciable conclusions attained in this research, a couple of limitations still exist, waiting for further perfection. For one thing, an overall probe has not yet been accomplished into these teaching activities, part of which were not explored due to their imperceptible failure modes. In addition, merely five individuals were given the expert questionnaires, all of which have been assembled and then evaluated. Given the opportunity of distributing the expert questionnaires among more targets, the outcome of this study would be slightly different. In the meantime, selecting several business executives or those veteran auto repair staff as the first batch of test objects is comparatively worthy of taking a crack at since the abundant practical experience from people of this category will definitely conduce to a more accurate feedback on these questionnaires. For the other, both the application and probe of FMEA into the educational industry are still in their infancy regardless of several decades' development of FMEA, consequently leading to the deficiency in relevant literature and publications that could be used for reference. Concerning the conclusions obtained in this research, subsequent perfections are still needed through further associative research. In light of the fact that the numerical ranking of RPN calculated within FMEA here was directly identified as the priority of improvement, follow-up scholars are suggested to use the complete quantitative values with reference to the RPN formula mode proposed in this research so that their research outputs would be more befitting and applicable in the education field. Likewise, attempts to use methods such as multi-criteria decision-making (MCDM) are also worth trying when assessing the failure mode. Last but not least, it is of the great potential that a fresher type of interpretation of the research outcomes will be garnered if that research is undertaken in other research areas.

Data Availability

The data will be made available upon request to the corresponding author.

Conflicts of Interest

The authors declare no conflicts of interest.

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