10.6977/IJoSI.201209_2(2).0004
W.J. Chang/ Int. J. Systematic Innovation, 2(2), 43-53 (2012)

# A New Perspective on EFL Teaching: Applying Fuzzy QFD in TRIZ for Teaching Quality Improvement

Wan-Jeng Chang

Department of Applied English, Overseas Chinese University, Taichung, Taiwan

E-mail: cwj@ocu.edu.tw

(Received 3 March 2014; final version received 29 April 2014)

**Abstract**

Teaching quality has been a frequently studied topic in education literature; however, a creative approach for improving teaching quality is rarely discussed. In this paper, a systematic framework based on the TRIZ methodology is suggested to generate creative solutions for improving teaching quality. First, the determinants of teaching quality were investigated based on a comprehensive review of language teaching. Subsequently, a parameter-corresponding table was developed to apply the TRIZ contradiction matrix effectively to solve language-teaching problems. Cochran test was used as a statistical hypothetic test during this phase. The correlation between "the vague opinions from the supplier and receptor of teaching" and "the determinants of teaching quality" was analyzed by using fuzzy QFD to identify the critical determinants related to teaching quality improvement. The corresponding parameters can be effectively applied in the TRIZ contradiction matrix to identify the inventive principles. The appropriate re-explanations of the inventive principles developed for foreign language teaching are discussed. A case study proved the usefulness of the approach in EFL courses, and practical solutions are presented to demonstrate the valuable contribution of the TRIZ methodology to the education field.

*Keywords:* Teaching quality, Teaching improvement, TRIZ, EFL, Fuzzy QFD

## 1. Overview

The teaching quality of universities has been increasingly emphasized since Boyer (1990) proposed expanding scholarship beyond teaching, integration, and application. Although educators have begun to realize the importance of improving teaching quality, the processes remain uncertain. Planning a university course is a complex activity (Barone & Lo Franco, 2009); therefore, enhancing teaching quality involves substantial shifts in thought and practice. In this study, a methodology for innovatively resolving teaching problems and improving teaching quality was developed to foster meaningful and long-term learning for students.

TRIZ (*Theoria Resheneyva Isobretatelskehuh Zadach*) is a Russian abbreviation for "theory of inventive problem solving," which is a well-developed system of tools used for idea generation, problem solving, and failure prevention (Akay, Demıray & Kurt, 2008; Belski, 2009). One tool, contradiction analysis, which consists of 39 parameters and 40 inventive principles, is the most frequently used method (Su & Lin, 2008). TRIZ is a popular subject regarding technological innovation (Mann, 2000) and has recently been proven to be an innovative and well-structured method for solving problems in non-technical fields (Mann, 2000; Saliminamin & Nezafati, 2003). However, there is a lack of TRIZ-specific research addressing the teaching quality domain, which is another reason for undertaking this study.

Quality function deployment (QFD) is a method for developing and managing products or services to assist planners in identifying product or service characteristics from the viewpoints of customers (Celik, Cebi, Kahraman & Er, 2009). The practice of QFD has primarily relied on market surveys for acquiring customer requirements, and planners typically employ linguistic variables to set various parameters. However, the outcomes of market surveys and linguistic variables are often imprecise or unclear and may reflect biased results. Scholars have combined the fuzzy set theory with QFD to solve this problem (Liu, 2011). In contrast to traditional QFD, the input data of fuzzy QFD are expressed

and represented in fuzzy numbers instead of crisp numbers (Chen, Fung, & Tang, 2006). In the current study, fuzzy QFD was used to identify critical teaching-quality determinants; this is crucial because numerous researchers have proposed that teaching is one of the primary services of a university (Harvey, 2003; Barone & Lo Franco, 2009).

In this study, the "quality" of a university course is defined as the degree to which the course satisfies the teaching expectations of the supplier and the receptor. Tribus (1993) stated that quality is what makes learning a pleasure and involves the way in which the teaching process is performed. In this regard, teachers and students are the primary parties responsible for achieving the goal of improved teaching quality. Accordingly, this paper addresses both teacher and student perspectives.

The study is structured as follows: Section 2 presents a review of the literature; Section 3 provides a description of the proposed approach; Section 4 presents the application of the proposed approach to English as a foreign language (EFL) courses; and Section 5 offers concluding remarks and suggestions for future developments.

## 2. Literature review

TRIZ offers a comprehensive toolkit for analyzing and solving problems according to various perspectives and is based on the knowledge and experiences of a wide range of inventors (Moehrle, 2005). The foundation study of TRIZ research was one of the largest studies on creativity conducted, involving more than 1,500 person-years of study and an analysis of more than two million patents globally (Mann, 2001; Zhang, Chai, & Tan, 2005). In this foundation study, an exceedingly small number of inventive patterns and strategies were identified and extracted (Mann, 2001). The strengths of TRIZ are described as follows. First, TRIZ encourages planners to break out of the conventional "begin with the present situation" style of thinking, and to start instead by considering ideality (Mann, 2001). Second, it transforms the undesirable elements of a system into useful resources and removes contradictions rather than encourages trade-offs or compromise (Mann, 2001; Zhang, et al., 2005; Su & Lin, 2008). Third, it helps to prevent psychological inertia, which is inherent in human thinking, because it involves devising a comprehensive set of feasible solutions (Zhang et al., 2005). Fourth, by providing a predefined direction, TRIZ complements and adds structure to, rather than replaces, an inventor's natural creativity (Mann, 2001; Moehrle, 2005). TRIZ facilitates developing numerous high-quality ideas effectively and systematically (Zhang et al., 2005).

The most commonly applied TRIZ tool is the contradiction matrix, which consists of 39 rows and 39 columns involving the 1,482 most common contradiction types (Mann, 2001). The rows of the matrix contain the desired factors of a system, whereas the columns comprise the harmful elements of a system. In each cross-field, up to 4 of 40 inventive principles are advised for eliminating the contradiction. Using different inventive principles occasionally generates similar ideas. The inventive principles lead planners in specific directions, but concrete solutions must be formed by combining inventive principles with the knowledge and creativity of the individual problem solver (Moehrle, 2005).

During years of development and application, TRIZ has proven its effectiveness and efficiency in resolving technical problems and in removing all boundaries across a broad range of areas and problem types (Mann, 2001). Several papers have presented discussions on the 40 inventive principles in various fields, such as business (Mann & Domb, 1999), finance (Dourson, 2004), society (Terninko, 2001), software (Rea, 2001), microelectronics (Retseptor, 2002), food (Mann, & Winkless, 2001), quality management (Retsptor, 2003), eco-innovation (Chang & Chen, 2003), construction (Teplitskiy & Kourmaev, 2005), service operations management (Zhang, Chai, & Tan, 2003), education (Marsh, Waters, & Marsh, 2004), and marketing, sales, and advertising (Retsptor, 2005). Several studies have also presented discussions on the parameters in the TRIZ contradiction matrix for non-technical fields, such as business (Mann, 2002), education (Marsh, Waters, & Mann, 2002), service quality (Su, Lin, & Chiang, 2008), and English learning (Sokol et. al., 2008). The literature on applying TRIZ in improving teaching quality has been limited, particularly in the area of foreign language teaching.

To strengthen their strong points (Tan, 2002), integrating TRIZ with other leading methods, such as QFD (Domb, 1998; Terninko, 1998; Schlueter, 2001; Yanashina, Ito, & Kawada, 2002), the theory of constraint (Stratton & Warburton, 2003), and Six Sigma (Verduyn, 2002), is a recent trend (Tan, 2002). Su and Lin (2008) proposed a systematic method for integrating fuzzy QFD and TRIZ to improve e-service quality. Because of their application success, the model of Su and Lin was

applied in this study to resolve problems in an EFL teaching context.

## 3. Proposed approach

Based on the literature review, the systematic problem-solving process used in previous research (Su, Lin, & Chiang, 2008; Su & Lin, 2008) was applied, with slight modifications, to improve teaching quality. The proposed approach comprises five primary phases.

Phase 1: Clarify the scope of the problem and distinguish the segment under which it is classified. Assisting problem solvers in clarifying the depth of the original problem requires identifying the specified area and focusing on resolving issues in the same segment. For instance, problems arising in EFL courses are classified under the segment of foreign language teaching. Consulting teachers and students to collect existing information on the possible problem is an easy and common practice for gathering situational information accurately. Function and attribute analysis (FAA) can also be used to access the root causes of the problem.

Phase 2: Extract the determinants affecting teaching quality from a review of various perspectives. Reference materials related to teaching quality are extensively analyzed to identify the critical characteristics regarding teaching quality improvement.

Phase 3: Develop a parameter-corresponding table for foreign language teaching. Once the resulting table of the identified segment is constructed, the assured TRIZ parameters can be efficiently extracted and applied in the contradiction matrix. This phase comprises five steps:

Step 3-1: Link the implications of the determinants assembled in Phase 2 with the TRIZ 39 engineering parameters according to their analogical interpretations. A survey of a focus group or several semi-structured interviews may be conducted in this step.

Step 3-2: Design a questionnaire based on the parameter-matching results in Step 3-1.

Step 3-3: Administer the questionnaire to a group of professionals to ensure their approval of the matching results. Determine that more than half of the specialists accept remarks as "accepted" or "rejected." Reform the rejected items according to specialists' suggestions until all of them are accepted.

Step 3-4 Confirm the relative effectiveness of the expert opinions on the parameter-matching results by using the Cochran test, a statistical test.

Step 3-5: According to the results of Step 3-4, construct a verified parameter-corresponding table for the segment of foreign language teaching. The specified contradiction matrix is now ready for use.

Phase 4: Originate the practicable solutions by using the TRIZ contradiction matrix. Following the indicated TRIZ inventive principles, all probable solutions may be generated through various discussions. This process is divided into the following steps:

Step 4-1: Describe the existing problems specifically and identify the elements of the existing problems based on the interviews conducted in Phase 1.

Step 4-2: Define the ideal situation to be achieved when the existing problems are solved.

Step 4-3: Apply fuzzy QFD with the entries of determinants from Phase 3 to indicate the critical determinants relevant to the existing problems. This step consists of five procedures.

(1) The importance of the relationship between teaching quality determinants from Phase 3 and the elements of the existing problems is described in linguistic terms with five distinct levels, namely, EI (extremely important), VI (very important), I (important), SI (slightly important), and NI (not important). The data can be collected from the opinions of selected teachers and students.

(2) The triangular fuzzy number is employed in this research, and all membership functions for the linguistic input data are standardized in the interval [0, 1]. The triangular fuzzy numbers {(0.75, 1, 1), (0.5, 0.75, 1), (0.25, 0.5, 0.75), (0, 0.25, 0.5), (0, 0, 0.25)} correspond to linguistic variables {"EI", "VI", "I", "SI", "NI"}, individually.

(3) Assume $T_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk})$ is the triangular fuzzy number of the $k^{th}$ team member assessing the correlative importance between the $j^{th}$ element of the existing problems and the $i^{th}$ entry of teaching quality determinants. Thus, $T_{ij}$ is the average fuzzy number of the $i^{th}$ entry of teaching quality determinants for the $j^{th}$ element of the existing problems. When $T_{ij} = (a_{ij}, b_{ij}, c_{ij})$ and $n$ = the number of team members, $T_{ij}$ can be calculated using the following equations:

$$T_{ij} = \frac{1}{n}\sum_{k=1}^{n} T_{ijk}$$

$$a_{ij} = \frac{1}{n}\sum_{k=1}^{n} a_{ijk}$$

$$b_{ij} = \frac{1}{n}\sum_{k=1}^{n} b_{ijk}$$

$$c_{ij} = \frac{1}{n}\sum_{k=1}^{n} c_{ijk}$$

Assume there is no weighting difference considered among the determinants of teaching quality, and, consequently, the integrated fuzzy number of each teaching quality determinant for $m$ team members $(A_i, B_i, C_i)$ can be calculated using the following equations:

$$A_i = \frac{1}{m}\sum_{j=1}^{m} a_{ij}$$

$$B_i = \frac{1}{m}\sum_{j=1}^{m} b_{ij}$$

$$C_i = \frac{1}{m}\sum_{j=1}^{m} c_{ij}$$

(4) Assume $X$ is the defuzzified value of the integrated fuzzy number for each teaching quality determinant $(A_i, B_i, C_i)$, and can be calculated using the following equation (Su & Lin, 2008):

$$X = \frac{A_i + B_i + B_i + C_i}{4}$$

(5) Based on the computed data, the prioritized significance of each relevant determinant can be ranked successively.

Step 4-4: Discuss the determinants that prevent the desirable situation from being achieved in the top region of the ranking list. The improving and worsening determinants can then be identified from the parameter-corresponding table developed in Phase 3.

Step 4-5: Based on the TRIZ contradiction matrix, indicate the intersection of the improving and worsening parameters and denote the numbers of the TRIZ 40 inventive principles.

Step 4-6: Identify the TRIZ 40 inventive principles that appear at least twice according to the outcome of Step 4-5.

Step 4-7: Based on relevant references, re-explain the inventive principles to suit the identified segment. Link the suggested principles to the existing problems and generate all viable solutions to eliminate the conflict points by discussion meetings.

Step 4-8: Examine the possible solutions and invite experts to rank them according to a set of decision-making criteria.

Phase 5: Implement the attainable solutions. If the existing problems are ineffectively solved, repeat the fourth stage until the conflicts are resolved.

## *4.* Case study

The studied school is a privately funded university in central Taiwan. To aid in a later career, all students are required to master at least one foreign language, specifically, English. The university language center proposed and implemented an English enhancement scheme in 2009. The goal of the scheme is to enhance the English ability of students in a short time. However, since the implementation of the new policy, several students have encountered various problems. In addition to the proficiency and achievement tests (in-class quizzes, mid-terms, and final exams), students are graded according to online learning tests, online learning practices, weekly vocabulary tests, a certificate of English proficiency test, and the English learning passport, which involves participating in English activities. Students are expected to acquire an abundance of knowledge in class and after school.

The case study focused on providing an efficient approach for generating ideas to resolve the problems regarding general English teaching in the university to improve EFL teaching quality. The author first interviewed three teachers and three freshmen who participated in the English enhancement scheme for 1 year. The results showed various contradictions within the scheme, and that TRIZ could be used to resolve the teaching problems.

Phase 1: In the studied case, the university language center is in charge of the general English courses for all students. The problems arising in EFL courses were classified under the segment of foreign language teaching. The FAA diagram in Fig. 1 was developed based on the aforementioned interviews.

Phase 2: In this phase, the author concentrated on various perspectives from the literature review to extract the main determinants of teaching quality in the specified segment. By categorizing the related academic studies within the scope of the case problem, the author concluded that teaching quality improvement is related to educational quality, teaching effectiveness, student achievement, student satisfaction, and potential teaching difficulties. The teaching quality determinants mentioned in this study may suit both EFL teaching and other undergraduate subjects.

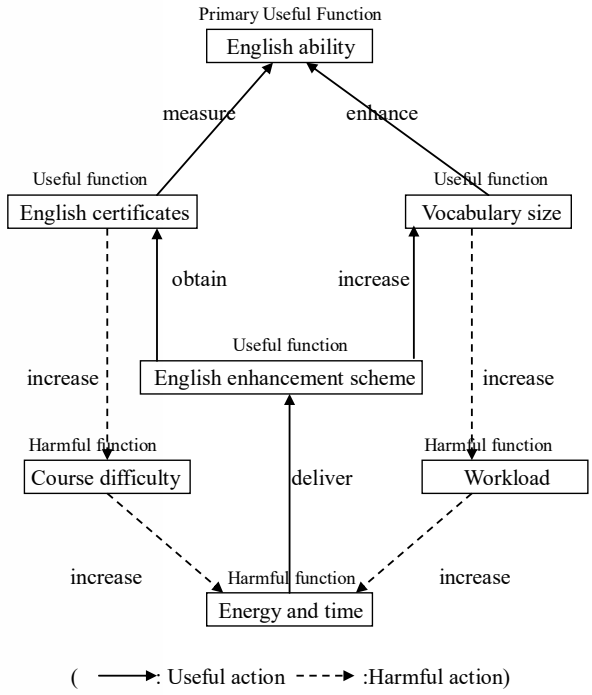


**Fig. 1.** The FAA diagram for the case study

Phase 3: The determinants of teaching quality developed in Phase 2 were analyzed and explained, and were subsequently correlated with the TRIZ 39 parameters. Semi-structured interviews with five experts in the fields of TRIZ, education, and EFL teaching were conducted to ensure a matching result.

The parameter-corresponding table is presented in Table 1. A TRIZ parameter may match more than one determinant of teaching quality. Furthermore, the determinants of teaching quality are not limited to those shown in Table 1. Each row of Table 1 represents the most similar analogical explanation between a determinant of teaching quality and a specific TRIZ parameter.

Subsequently, the author designed a questionnaire explaining each parameter, and five EFL teachers from the university were invited to answer the questionnaires with their professional opinions. Each item gained the approval of at least three specialists.

The Cochran test was used to confirm the consistency of the specialists' opinions on the parameter-corresponding results, which led to the development of the following null hypotheses:

$H_0$: No meaningful difference exists among the opinions.

$H_1$: A meaningful difference exists among the opinions.

"1" was used to express agreement with the matching result, and "0" was used to express rejection. The results were tabulated using c columns (c specialists) and r rows (r determinants). Each entry in the table was either "1" or "0." Ri was the row totals (i = 1, 2, . . .., r), Cj was the column totals ( j = 1, 2, . . .., c), and N was the total number of "1" values in the table. The test statistic was calculated using the following equation:

$$T = c(c-1)\frac{\sum_{j=1}^{c}(C_j - \frac{N}{c})^2}{\sum_{i=1}^{r} R_i(c-R_i)} = 5\times 4\times \frac{14}{34} = 8.235$$

The computed statistic value of T was smaller than the critical value 9.488. The null hypothesis $H_0$ was accepted. Therefore, the 29 pairs of matching parameters were valid.

**Table 1.** Parameter-corresponding Table

| No. of TRIZ parameter | Name of TRIZ parameter | Determinants of teaching quality | References |
|---|---|---|---|
| 1<br>3<br>5<br>7<br>15<br>19 | A mobile object | E-learning (web-assisted or web-based courses) | Liaw, Huang, & Chen (2007)<br>Fichten et al. (2009)<br>Liaw et al. (2007)<br>Waschull (2001)<br>Desai, Hart, & Richard (2008)<br>Faul, Frey, and Barber (2004)<br>Uzunboylu (2005) |
| 2<br>4<br>6<br>8<br>16<br>20 | A stationary object | Traditional classroom instruction | Stephenson, McGuirk, Zeh, & Reeves (2005) |
| 9 | Speed | The pace of a lesson | Greenblatt, Cooper, & Muth (1984)<br>Feldman (1989) |
| 10 | Force | Group interaction | Phillips, Santoro, & Kuehn (1988)<br>Marsh & Bailey (1993)<br>Chickering & Gamson (1991) |
| 11 | Tension/ Pressure | Pressure or stress of students | Hughes (2005)<br>Byrne & Flood (2003)<br>Ginnsa, Prosserb & Barriea (2007) |
| 12 | Shape | Overall course impression | Harrison, Douglas, & Burdsal (2004) |
| 13 | Stability of composition | Well-designed curriculum | Walker (2003)<br>Holley (2009) |
| 14 | Strength | Professionalism of instructors | Glenn (2001)<br>Jumani & Yousuf Zai (2009)<br>Eilam & Poyas (2006) |
| 17 | Temperature | Classroom atmosphere | Glenn (2001)<br>Feldman (1989) |
| 18 | Brightness | Learning environment | Jumani & Yousuf Zai (2009)<br>Beattie & Collins (2000)<br>Strolin-Goltzman (2010) |
| 21 | Power | Enthusiasm and efforts of teachers | Minchella (2007) |
| 22 | Loss of energy | Excessive workload | Harrison, Douglas, & Burdsal (2004)<br>Feldman (1989)<br>Byrne & Flood (2003) |
| 23 | Loss of a substance | Maintenance of facilities and equipment | Beattie & Collins (2000) |
| 24 | Loss of information | Selected course content | Sözbilir (2004) |
| 25 | Loss of time | Spending time on classroom management | Van de Grift (2007) |
| 26 | Amount of substance | Adequate facilities and equipment | Beattie & Collins (2000) |
| 27 | Reliability | Teachers' self-efficacy | Fives & Buehl (2010)<br>Klassen & Chiu (2010) |
| 28 | Accuracy of measurement | Accuracy of grading | Harrison, Douglas, & Burdsal (2004)<br>Beattie & Collins (2000)<br>Jumani & Yousuf Zai (2009) |
| 29 | Accuracy of manufacturing | Aligning teaching and assessing with course objectives | Biggs (1996) |
| 30 | Harmful factors acting on an object from outside | Unnecessary interruptions | Greenblatt, Cooper, & Muth (1984)<br>Kennedy (2006) |
| 31 | Harmful factors developed by an object | Disruptive student behavior | Kennedy (2006) |
| 32 | Manufacturability | The degree of class difficulty | Harrison, Douglas, & Burdsal (2004) |
| 33 | Convenience of use | Convenience of finding support | Klem & Connell (2004) |
| 34 | Reparability | Reflective teaching | Farrell (1998) |
| 35 | Adaptability | Flexibility in teaching (to respond to external environment or to meet student needs) | Feldman (1989)<br>Zahorik (1990)<br>Knight (1999)<br>Glenn (2001) |
| 36 | Complexity of a device | Complexity of a grading policy | Sadler (2005)<br>Linn, Baker, & Dunbar (1991) |
| 37 | Complexity of control | Complexity of the issues involved in grading | Guskey (2000)<br>Wood (1994) |
| 38 | Level of automation | Self-initiated learning | Feldman (1989)<br>Beattie & Collins (2000)<br>Van de Grift (2007) |
| 39 | Capacity/ Productivity | Expectations for student performance | Beattie & Collins (2000)<br>Chickering & Gamson (1991) |

Phase 4: According to the results of FAA, the scope of the problem comprised the areas of vocabulary size, English certificates, course difficulty, and workload. These four were the elements of existing problems, and the author defined the ideal situation as the provision of a supportive and motivating environment for students to enhance their English ability without undertaking heavy workloads.

The fuzzy QFD process was initiated to identify the critical teaching quality determinants. The correlative importance between the teaching quality determinants from Phase 3 and elements of the existing

problems was determined in linguistic terms based on the opinions of the three teachers and three students who participated in the English enhancement scheme for 1 year. The integrated triangular fuzzy numbers and the rankings of their importance are shown in Table 2.

**Table 2.** Integrated Triangular Fuzzy Numbers and the Rankings of their Importance

| No. of Teaching Quality Determinant | Integrated Triangular Fuzzy Number | | | Defuzzied Fuzzy Number | Ranking of Importance |
|---|---|---|---|---|---|
| | $A_i$ | $B_i$ | $C_i$ | | |
| 1 | 0.250 | 0.458 | 0.698 | 0.466 | 13 |
| 2 | 0.365 | 0.615 | 0.865 | 0.615 | 4 |
| 3 | 0.333 | 0.500 | 0.698 | 0.508 | 8 |
| 4 | 0.094 | 0.239 | 0.489 | 0.265 | 25 |
| 5 | 0.188 | 0.365 | 0.604 | 0.380 | 19 |
| 6 | 0.188 | 0.375 | 0.625 | 0.390 | 18 |
| 7 | 0.313 | 0.531 | 0.771 | 0.536 | 7 |
| 8 | 0.198 | 0.396 | 0.635 | 0.406 | 16 |
| 9 | 0.198 | 0.386 | 0.604 | 0.393 | 17 |
| 10 | 0.032 | 0.177 | 0.427 | 0.203 | 28 |
| 11 | 0.219 | 0.417 | 0.667 | 0.430 | 15 |
| 12 | 0.230 | 0.427 | 0.646 | 0.432 | 14 |
| 13 | 0.073 | 0.187 | 0.437 | 0.221 | 26 |
| 14 | 0.042 | 0.115 | 0.365 | 0.159 | 29 |
| 15 | 0.250 | 0.458 | 0.698 | 0.466 | 12 |
| 16 | 0.084 | 0.250 | 0.500 | 0.271 | 23 |
| 17 | 0.459 | 0.698 | 0.886 | 0.685 | 2 |
| 18 | 0.115 | 0.261 | 0.511 | 0.287 | 22 |
| 19 | 0.313 | 0.510 | 0.698 | 0.508 | 10 |
| 20 | 0.292 | 0.500 | 0.740 | 0.508 | 9 |
| 21 | 0.104 | 0.312 | 0.562 | 0.323 | 21 |
| 22 | 0.375 | 0.573 | 0.761 | 0.570 | 5 |
| 23 | 0.375 | 0.625 | 0.875 | 0.625 | 3 |
| 24 | 0.156 | 0.354 | 0.594 | 0.364 | 20 |
| 25 | 0.323 | 0.573 | 0.781 | 0.562 | 6 |
| 26 | 0.094 | 0.240 | 0.490 | 0.266 | 24 |
| 27 | 0.073 | 0.177 | 0.427 | 0.213 | 27 |
| 28 | 0.615 | 0.865 | 0.958 | 0.826 | 1 |
| 29 | 0.302 | 0.500 | 0.709 | 0.503 | 11 |

The author regarded the first five ranked determinants as the primary characteristics influencing student learning regarding participation in the English enhancement scheme. The selected determinants were self-initiated learning, teachers' self-efficacy, convenience of finding support, traditional classroom instruction, and the degree of class difficulty.

To achieve the ideal situation, the five identified important determinants must be improved. However, this involves several issues. First, encouraging self-regulated learning may require increasing peer interaction and professor interaction. Interaction gives learners the opportunity to model behaviors and to measure their progress, which in turn increases the motivation to learn. Second, improving the self-efficacy of instructors requires extra in-service training. Teachers must spend more time participating in related workshops or seminars. Third, providing more support and offering additional courses increase the workload of teachers. Teachers must increase their efforts to satisfy student needs. Fourth, lowering the coverage rate and the level and amount of material may affect the productivity of students. Teachers may need to lower their expectations for student performance.

Table 3 shows improving TRIZ parameters, the corresponding worsening TRIZ parameters, and the number of TRIZ inventive principles in the intersection of the improving and worsening TRIZ parameters. The principles that occurred at least twice were No. 2, 10, 28, and 35.

**Table 3.** Improving and Worsening TRIZ Parameters and the Related Inventive Principles

| Improving TRIZ Parameters | Worsening TRIZ Parameters | Number of Inventive Principles |
|---|---|---|
| 38 | 10 | 2 35 |
| 27 | 14 | 11 28 |
| 33 | 21 | 2 10 34 35 |
| 2 | 21 | 15 18 19 22 |
| 4 | 21 | 8 12 |
| 6 | 21 | 17 32 |
| 8 | 21 | 6 30 |
| 16 | 21 | 16 |
| 20 | 21 | |
| 32 | 39 | 1 10 28 35 |

The author analyzed each of the inventive principles from the related studies and discussed them with the three teachers and three students who participated in the English enhancement scheme for 1 year to generate ideas for solutions. The study of Marsh et al. (2004), which provides educational examples of the 40 inventive principles, was the primary reference in the discussions.

The first idea was based on Principle 2, extraction. A remedial program can be established, and students with special needs should be separated from the general student population (Marsh et al., 2004). Teachers can arrange meetings with students who require additional assistance. The meetings can be conducted to review course content, emphasize key points, and provide additional practice.

The second idea was developed based on Principle 10, prior action. The accuracy of the placement test must improve. The current type of question is multiple choices, which is too simple for adequately determining the ability of students. Students who enter a class that is not suited to their ability encounter problems. Increasing

the number and variety of placement test questions may facilitate determining the actual level of student ability.

The third idea was derived from Principle 2. Students in the studied university were classified according to their placement test performance: superior, intermediate, and average. Students should study materials suited to their English ability. Students should be classified into more than three levels.

The fourth idea was based on Principle 35, transformation of the physical and chemical states of an object. Numerous students do not appropriately equip themselves to study current courses. They must enhance their basic skills, such as phonetic symbols, pronunciation, and grammar. Intensive courses can improve students' skills in a short period of time. These basic courses can be taught during nights, weekends, and summer and winter vacations for a small tuition fee.

The fifth idea was based on Principle 35. Teachers can reduce the volume of vocabulary taught throughout the semester, but assign homework during summer (2 months) and winter (1 month) vacations. Therefore, students can reduce their workload, reducing the probability that they neglect their studies during the semester.

The sixth idea was based on Principle 35. The university offers English classes only for freshmen and sophomores. Instead of teaching a substantial amount of content in the first 2 years, it may be useful to provide courses throughout the 4 years of undergraduate study. Offering English courses to junior and senior students may enhance their learning.

The source of the seventh idea was Principle 35. The general English course is 2 hr per week. Because teachers are unable to teach all the content in 2 hr, it may help to add 1 more hr to the course. Three hours per week gives teachers sufficient time cover all the course content.

The eighth idea was based on Principle 28, replacement of a mechanical system. Teachers can divide students into groups consisting of both high and low achievers. Those who perform highly are responsible for tutoring the others. The study group provides opportunities for students to model desired behaviors.

The ninth idea was based on Principle 35. The university offers courses for preparing English certificates, but only a certain number of students enroll in these classes because of the cost. The school can provide additional classes for all students who want to join the program for a small fee.

These nine ideas were prioritized in the grading from 1 to 10 and were evaluated by five teachers from the university. Cost, time, and manpower were the three criteria considered when making the final decision. The nine ideas were arranged according to priority as follows: Idea 9, 6, 2, 8, 7, 5, 3, 4, and 1.

Phase 5: The school was suggested to implement these nine ideas according to their priority. The results of the implementation are not demonstrated in this case study. Researchers may consider evaluating the results in future studies.

## 5. Conclusion

The contribution of this study to EFL teaching is the suggestion of a creative approach to improving teaching quality, a contribution that provides a considerable boost toward solving teaching problems. This study also fills gaps in previous research on TRIZ by constructing teaching quality determinants that correlate with the TRIZ 39 parameters. Although the verified parameter-corresponding table may not reflect all the distinct patterns of teaching quality, implementing the proposed approach would produce a considerable effect on the education field.

## References

Akay, D., Demıray, A., and Kurt, M. (2008). Collaborative tool for solving human factors problems in the manufacturing environment: the Theory of Inventive Problem Solving Technique (TRIZ) method. *International Journal of Production Research, 46*(11), 2913-2925.

Barone, S. and Lo Franco, E. (2009). Design of a university course quality by Teaching Experiments and Student Feedback (TESF). *Total Quality Management & Business Excellence, 20*(7), 687-703.

Beattie, V. and Collins, B. (2000). Teaching quality assessment in accounting: The Scottish experience. *Accounting Education, 9*(1), 1-22.

Belski, I. (2009). Teaching thinking and problem solving at university: A course on TRIZ. *Creativity & Innovation Management, 18*(2), 101-108.

Biggs, J. (1996). Enhancing teaching through constructive alignment. *Higher Education, 32*, 347-364.

Boyer, E. L. (1990). *Scholarship Reconsidered: Priorities of the Professoriate.* Princeton, NJ: The Carnegie Foundation for the Advancement of Teaching

Byrne, M., and Flood, B. (2003). Assessing the teaching quality of Accounting programmes: An evaluation

of the course experience questionnaire. *Assessment and Evaluation in Higher Education, 28*(2), 135-145.

Celik, M., Cebi, S., Kahraman, C., and Er, I. D. (2009). An integrated fuzzy QFD model proposal on routing of shipping investment decisions in crude oil tanker market. *Expert Systems with Applications, 36*, 6227-6235.

Chang, H. T. and Chen, J. W. (2003). Eco-innovative examples for 40 TRIZ Inventive principle. *The TRIZ Journal, Aug*.

Chickering, A.W. and Gamson, Z.F. (Eds.). (1991). *New directions for teaching and learning: Vol. 47. Applying the seven principles for good practice in undergraduate education*. San Francisco: Jossey-Bass.

Chen, Y., Fung, R. Y. K., and Tang, J. (2006). Rating technical attributes in fuzzy QFD by integrating fuzzy weighted average method and fuzzy expected value operator. *European Journal of Operational Research, 174*(3), 1553-1566.

Desai, M. S., Hart, J., and Richard, T. C. (2008). E-learning: Paradigm shift in education. *Education, 129*(2), 327-334.

Domb, E. (1998). QFD and TIPS/TRIZ. *The TRIZ Journal, Jun*.

Dourson, S. (2004). The 40 Inventive Principles of TRIZ Applied to Finance. *The TRIZ Journal, Oct*.

Eilam, B. and Poyas, Y. (2006). Promoting awareness of the characteristics of classrooms' complexity: A course curriculum in teacher education. *Teaching and Teacher Education, 22*(3), 337-351.

Ellen, D. (1998). The 39 features of Altshuller's contradiction matrix. *The TRIZ Journal, Nov*.

Farrell, T. (1998). Reflective teaching: The principles and practices. *English Teaching Forum, 36*(4), 10 – 17.

Faul, A. C., Frey, A. J., and Barber, R. (2004). The effects of web-assisted instruction in a social work research methods course. *Social Work Education, 23*(1), 105-118.

Feldman, K. A. (1989). The association between student ratings of specific instructional dimensions and student achievement: Refining and extending the synthesis of data from multisection validity studies. *Research in Higher Education, 30*(6), 583-645

Fichten, C. S., Asuncion, J.V., Barile, M., Ferraro, V., and Wolforth, J. (2009). Accessibility of e-learning and computer and information technologies for students with visual impairments in postsecondary education. *Journal of Visual Impairment & Blindness, 103*(9), 543-557.

Fives, H. and Buehl, M. M. (2010). Examining the factor structure of the teachers' sense of efficacy scale. *The Journal of Experimental Education, 78*(1), 118-134.

Ginnsa, P., Prosserb, M., and Barriea, S. (2007). Students' perceptions of teaching quality in higher education: The perspective of currently enrolled students. *Studies in Higher Education, 32*(5), 603-615.

Glenn, R. E. (2001). What teachers need to be. *Education Digest, 67*, 19-21.

Greenblatt, R. B., Cooper, B. C. and Muth, R. (1984). Managing for effective teaching. *Educational Leadership, 41*(5), 57-59.

Guskey, T. R. (2000). *Developing grading and reporting systems for student learning*. Thousand Oaks, CA: Corwin Press.

Harrison, P.D., Douglas, D.K., and Burdsal, C.A. (2004). The relative merits of different types of overall evaluations of teaching effectiveness. *Research in Higher Education, 45*(3), 311-323.

Harvey, L. (2003). Student feedback. *Quality in Higher Education, 9*(1), 3-20.

Holley, K. (2009). The challenge of an interdisciplinary curriculum: A cultural analysis of a doctoral-degree program in neuroscience. *Higher Education, 58*(2), 241-255.

Hughes, B. M. (2005). Study, examinations, and stress: Blood pressure assessments in college students. *Educational Review, 57*(1), 21-36.

Jumani, N. B. and Yousuf Zai, Z. I. (2009). Distance teacher education in Pakistan. *Quarterly Review of Distance Education, 10*(4), 381-389.

Kennedy, M. M. (2006). From teacher quality to quality teaching. *Educational Leadership, 63*(6), 14-19.

Klassen, R. M. and Chiu, M. M. (2010). Effects on teachers' self-efficacy and job satisfaction: Teacher gender, years of experience, and job stress. *Journal of Educational Psychology, 102*(3), 741-756.

Klem, A. M. and Connell, J. P. (2004). Relationships matter: Linking teacher support to student engagement and achievement. *Journal of School Health, 74*(7), 262-273.

Knight, B. A. (1999). Towards inclusion of students with special educational needs in the regular classroom. *Support for Learning, 14*(1), 3-7.

Liaw, S. S., Huang, H. M., and Chen, G. D. (2007). Surveying instructor and learner attitudes toward e-learning. *Computers & Education, 49*(4), 1066–1080.

Linn, R. L., Baker, E., and Dunbar, S. B. (1991). Complex, performance-based assessment: expectations and validation criteria. *Educational Researcher, 20*(8), 15-21.

Liu, H. T. (2011). Product design and selection using fuzzy QFD and fuzzy MCDM approaches. *Applied Mathematical Modelling, 35*(1), 482-496.

Mann, D. and Domb, E. (1999). 40 inventive (Business) principles with examples. *The TRIZ Journal, Sep*.

Mann, D. and Winkless, B. (2001). 40 inventive (food) principles with examples. *The TRIZ Journal, Jul*.

Mann, D. (2000). Application of TRIZ tools in a non-technical problem context. *The TRIZ Journal, Aug*.

Mann, D. (2001). An introduction to TRIZ: The theory of inventive problem solving. *Creativity and Innovation Management, 10*(2), 123-125.

Mann, D. (2002). Systematic win-win problem solving in a business environment. *The TRIZ Journal, Apr*.

Marsh, D. G., Waters, F. H., and Mann, D. L. (2002). Using TRIZ to resolve educational delivery conflicts inherent to expelled students in Pennsylvania. *The TRIZ Journal, Nov*.

Marsh, D. G., Waters, F. H., and Marsh, T. D. (2004). 40 inventive principles with applications in education. *The TRIZ Journal, Apr*.

Marsh, H. W. and Bailey, M. (1993). Multidimensional students' evaluations of teaching effectiveness: A profile analysis. *Journal of Higher Education, 64*(1), 1-18.

Minchella, D. J. (2007). R.E.S.P.E.C.T. - A teaching primer. *Journal of College Science Teaching, 36*(7), 12-13.

Moehrle, M. G. (2005). What is TRIZ? From conceptual basics to a framework for research. *Creativity and Innovation Management, 14*(1), 3–13.

Phillips, G. M., Santoro, G. M., and Kuehn, S. A. (1988). The use of computer-mediated communication in training students in training students in group problem-solving and decision-making techniques, *The American Journal of Distance Education, 2*, 38-51.

Rea, K. C. (2001). TRIZ and software- 40 principle analogies, part 1. *The TRIZ Journal, Sep*.

Retseptor, G. (2002). 40 inventive principles in microelectronics. *The TRIZ Journal, Aug*.

Retseptor, G. (2003). 40 inventive principles in quality management. *The TRIZ Journal, Mar*.

Retseptor, G. (2005). 40 inventive principles in marketing, sales and advertising. *The TRIZ Journal, Apr*.

Sadler, D. R. (2005). Interpretations of criteria-based assessment and grading in higher education. *Assessment & Evaluation in Higher Education, 30*(2), 175-194.

Saliminamin, M. H. and Nezafati, N. (2003). A new method for creating non-technological principles of TRIZ. *The TRIZ Journal, Oct*.

Schlueter, M. (2001). QFD by TRIZ. *The TRIZ Journal, Jun*.

Sokol, A., Oget, D., Sonntag, M., and Khomenko, N. (2008). The development of inventive thinking skills in the upper secondary language classroom. *Thinking Skills and Creativity, 3*(1), 34-46.

Sözbilir, M. (2004). What makes physical chemistry difficult? Perceptions of Turkish chemistry undergraduates and lecturers. *Journal of Chemical Education, 81*(4).

Stephenson, K., McGuirk, A., Zeh, T., and Reeves, D.W. (2005). Comparisons of the educational value of distance delivered versus traditional classroom instruction in introductory agricultural economics. *Review of agricultural economics, 27*(4), 605-620.

Stratton, R. and Warburton, R. D. H. (2003). The strategic integration of agile and lean supply. *International Journal of Production Economics, 85*(2), 183-198.

Strolin-Goltzman, J. (2010). The relationship between school-based health centers and the learning environment. *Journal of School Health, 80*(3), 153-159.

Su, C. T. and Lin, C. S. (2008). A case study on the application of Fuzzy QFD in TRIZ for service quality improvement. *Quality & Quantity, 42*(5), 563-578.

Su, C. T., Lin, C. S., and Chiang, T. L. (2008). Systematic improvement in service quality through TRIZ methodology: An exploratory study. *Total Quality Management & Business Excellence, 19*(3), 223-243.

Tan, R. (2002). Voice of customers pushed by directed evolution. *The TRIZ Journal, Jun*.

Teplitskiy, A. and Kourmaev, R. (2005). Application of 40 inventive principles in construction. *The TRIZ Journal, May*.

Terninko, J. (1998). The QFD, TRIZ and Taguchi connection: Customer-driven robust innovation. *The TRIZ Journal, Jan*.

Terninko, J. (2001). 40 inventive principles with social examples. *The TRIZ Journal, Jun*.

Tribus, M. (1993). Quality management in education. *Journal of Quality and Participation, 16*(1).

Uzunboylu, H. (2005). The Tools of the web assisted foreign language instruction. (*ERIC Document Reproduction Service No. ED490529*).

Van de Grift, W. (2007). Quality of teaching in four European countries: a review of the literature and application of an assessment instrument. *Educational Research, 49*(2), 127-152.

Verduyn, D. (2002). Integrating innovation into design for six sigma. *The TRIZ Journal, Feb*.

Walker, D. (2003). *Fundamentals of curriculum: Passion and professionalism*. Mahwah, NJ: Lawrence Erlbaum Associates.

Waschull, S. B. (2001). The online delivery of psychology courses: Attrition, performance, and evaluation. *Teaching of Psychology, 28*(2), 143-147.

Wood, L. A. (1994). An unintended impact of one grading practice. *Urban Education, 29*(2), 188–201.

Yanashina, H., Ito, T., and Kawada, H. (2002). Innovative product development process by integrating QFD and TRIZ. *International Journal of Production Research, 40*(5), 1031-1050.

Zahorik, J. A. (1990). Stability and flexibility in teaching. *Teaching and Teacher Education, 6*(1), 69-80.

Zhang, J., Chai, K. H., and Tan, K. C. (2003). 40 inventive principles with applications in service operations management. *The TRIZ Journal, Dec*.

Zhang, J., Chai, K. H., and Tan, K. C. (2005). Applying TRIZ to service conceptual design: An exploratory study. *Creativity and Innovation Management, 14*(1), 34-42.

## AUTHOR BIOGRAPHIES

**Dr. Wan-Jeng Chang** had been in the United States for over seven years. In that period of time, she got her master's and doctor's degree. She had earned concentrations in both Business Communication and TESOL as part of her doctoral studies in education. She is currently an assistant professor in the Department of Applied English, Overseas Chinese University, Taiwan.