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A study on the relationship between mechanical engineering teachers' creative teaching and students' technological creativity at vocational high schools in Taiwan

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ABSTRACT: The main purpose of this study is to find out the correlation paths between mechanical engineering teachers' creative teaching and students' technological creativity at vocational high schools in Taiwan in order to improve teaching strategies. The researcher adopted document analysis and a questionnaire survey. The subjects in the questionnaire investigation were mechanical engineering senior students. Cluster random sampling was used to collect 203 students' data, with 199 effective students' answers being obtained, yielding an effective rate of recovery of 98%. The data was analysed by frequency, mean, Kolmogorov-Smirnov Z test and canonical correlation analysis. It was concluded that mechanical engineering teachers' creative teaching in vocational high schools included three important elements, while mechanical engineering students' technical creativity comprised five key elements. The actual conditions of mechanical engineering teachers' creative teaching only reached a *fair* degree. The actual conditions of mechanical engineering students' technological creativity only reached a *good* degree. Different mechanical engineering teachers' creative teaching methods have various impacts on the levels of students' technical creativity.

RESEARCH MOTIVATIONS AND BACKGROUNDS

In the face of the fierce international competition, all industry in Taiwan is experiencing strong competitive pressure due to management and environmental changes. Technological innovation has become the most effective means of improving an enterprise's competitive power. Science and technology is constantly innovating and production technology is being updated. As such, *technological creativity* becomes the most important developmental resource of a country and provides a foundation for national economic development. In order to advance a nation's economy and to facilitate national modernised development, attention must be given to the high quality of training for the professional workforce so as to constantly advance the most efficient productivity levels, improve a producer's quality of work and guarantee national competitiveness.

Technological creativity has an obvious function to foster innovation and changes to economic production technology. The so-called technological creativity is the innovation ability of an individual who has the knowledge, skills and skilful technological experience accumulated from learning through quickly thinking, an enthusiastic and persistent attitude, a willingness to help others, show high performance and achieve the goal of innovation [1]. Many countries have taken action to develop the method, promotion tactics and the fostering of technological creativity for schools and enterprises in order to promote national economic development [2][3].

Huang clearly points out that the process of using technology to create products, apart from an individual's personality, is influenced by external environmental conditions and education [1]. With respect to education, a student's consciousness of the teacher's role, style and teaching tactics shows that creativity is fostered by the learning experience [4]. *Creative teaching* means that teachers use creative teaching design, teaching strategies, etc, to promote students to become familiar with basic skills, understand concepts in-depth, produce one's own comprehension, use information and mould their creativity [5]. As such, the relation between technological creativity *teaching* and *learning* is worth being explored.

The main purpose of vocational education is the transmission, learning and innovation of knowledge and technology in order to realise a purpose. Teachers should construct a situation to promote learning and utilise various kinds of creative teaching measures to foster students' learning [6]. The machinery industry is an important industry of a country; in a situation where natural resources are extremely limited, technological creativity is turned into the most important resource and capital for economic activity. Mechanical engineering is the main department at a vocational high school with many students being educated there, to train technicians and influence economic activity. So it is necessary to have a systematic study of the relation between teacher's creative teaching and student's technological creativity [7][8].

RESEARCH DESIGN AND PRACTICES

Research Methods and Targets

The author collected research documents and references about *technological creativity* and conducted a content analysis, then drew conclusions in accordance with the need to establish the direction of study and compile a *Mechanical Engineering Student Technological Creativity Scale*.

In accordance with the literature review and document analysis, the author compiled two questionnaires. Cluster random sampling was then used to collect data from 203 senior students from five classes in four vocational high schools' mechanical engineering departments. There were 199 effective answers obtained, yielding an effective recovery rate of 98%.

Research Instruments

To explore the research topic of *technological creativity*, a document analysis was first conducted. The research reliability and validity depended on the researcher's experience, training, background, status, etc. Having been engaged in social science research for a long time, the researcher had a suitable level of experience to carry out this work. In conclusion, the researcher often made use of training, thinking and introspection, etc, and tried to maintain the accuracy and dependability of the course of the research and the results.

Two questionnaires were compiled to determine students' points of view. The form was designed to a Likert 5-scale method. The expert validity was constructed by four scholars and a written examination, with content validity confirmed and the questionnaires' text polished.

Mechanical Engineering Students' Consciousness of Teachers' Creative Teaching Questionnaire

This questionnaire is revised from Chiang's *Creative Teaching Questionnaire* [8]. The basic content of the questionnaire was established using the Delphi method, then revised from the students' viewpoint in order to examine the actual conditions of mechanical engineering teachers' *creative teaching*. The scale included three major parts: characteristics of creative teaching, process of creative teaching and strategies for creative teaching. This amounted to 32 questions, as Table 1 shows.

Table 1: Content of the questionnaire for students' consciousness of teachers' creative teaching.

Dimension	No. of Items
The characteristics of creative teaching	14
The process of creative teaching	5
The strategies of creative teaching	13
Total	32

Mechanical Engineering Student's Technological Creativity Scale

This questionnaire is revised from Huang's *Scales of Technical Creativity* and Tang's *Test of Specialised Creativity in the Machine Shop* [1][7]. These were utilised to assess the actual conditions of mechanical engineering student's technological creativity. The scale included five major parts: specialised knowledge, sensitivity and quick-response, skilful technique, positive attitude and perseverance. This amounted to 35 questions, as listed in Table 2.

Table 2: Content of the scale for mechanical engineering students' technological creativity.

Dimension	No. of Items
Specialised knowledge	7
Sensitivity and quick-response	7
Skilful technique	7
Positive attitude	7
Perseverance	7
Total	35

Data Analysis Methods

The process of analysing the document was undertaken to enhance the reliability of the research. The related confirmation of phenomena was carried out according to triangulation and cross-checking methods, referring to comparisons of different sources of data to confirm the authenticity of the contents. The methods for analysing the questionnaires data was as follows:

- Descriptive statistics to analyse the inclination of each construct and the whole scale by frequency and mean;
- Kolmogorov-Smirnov Z test (a test for goodness of fit) to seek the conformation degree of the actual conditions of each dimension of the two questionnaires, consistency inclinations of all the samples are tested separately;
- Canonical correlation analysis to explore the maximum correlation between the independent variable set and dependent-variable set, typical coefficient correlation represent the relationship; if significant, then the two sets are related.

ANALYSIS OF RESEARCH DATA

Analysis of Document Data

The results of analysing the documents concerning technological creativity are listed in Table 3. Among the five dimensions, the most frequent is skilful technique (13 times), with the least frequent being *perseverance* (9 times).

Table 3: Frequency for mechanical engineering student's technological creativity.

Dimension	Frequency
Specialised knowledge	11
Sensitivity and quick-response	10
Skilful technique	13
Positive attitude	10
Perseverance	9

Data Analysis of the Questionnaire on Mechanical Engineering Students' Consciousness of Teachers' Creative Teaching

Table 4 shows the conformation degree of the mechanical engineering students' consciousness of teachers' creative teaching, with a mean of 3.56. Of the conformation degree's dimensions, *strategies of creative teaching* was the lowest (mean=3.53) and *characteristics of creative teaching* was the highest (mean=3.60). On the whole, the mean of the conformation degree of all the dimensions was greater than 3.50.

Table 4: Mean and sequence for the conformation degree of students' consciousness of teachers' creative teaching.

Dimension	Sequence	Mean
Characteristics of creative teaching	1	3.60
Process of creative teaching	2	3.54
Strategies for creative teaching	3	3.53
Whole		3.56

N=199

Consistency Test for the Conformation Degree of Mechanical Engineering Students' Consciousness of Teachers' Creative Teaching

Table 5 shows the result of the consistency test for the conformation degrees of the students' consciousness of teachers' creative teaching, with all dimensions' data being significant (Kolmogorov-Smirnov Z scores were 10.91***, 6.31*** and 9.78***, respectively).

Table 5: Consistency test for the conformation degree of the students' consciousness of teachers' creative teaching.

Dimension	N	Most Extreme Differences			Kolmogorov-Smirnov Z
		Absolute	Positive	Negative	
Characteristics of creative teaching	2,786	0.21	0.17	-0.21	10.91 ***
Process of creative teaching	995	0.20	0.16	-0.20	6.31 ***
Strategies for creative teaching	2,587	0.19	0.17	-0.19	9.78 ***
Whole	6,368	0.20	0.17	-0.20	15.95 ***

***p<0.001; N=Number of items x the effective sample counting.

It was found that in the actual teaching situation, the conformation degree of all three aspects of the mechanical engineering students' consciousness of teachers' creative teaching is consistent, with the mean being higher than 3.53.

Data Analysis of Mechanical Engineering Students' Technological Creativity Scale

Table 6 shows the mean of the whole conformation degree of mechanical engineering students' consciousness of one's own technological creativity to be 3.81. Among the consciousness degree of each dimension, *perseverance* was the lowest (mean=3.56), while *sensitivity and quick response* was the highest (mean=3.88). On the whole, the mean of the conformation degree of all the dimensions was greater than 3.50.

Table 6: Mean for conformation degree of mechanical engineering student's technological creativity.

Dimension	Sequence	Mean
Specialised knowledge	3	3.87
Sensitivity and quick response	1	3.88
Skilful technique	4	3.87
Positive attitude	2	3.88
Perseverance	5	3.56
Whole		3.81

N=199

Table 7 shows the result of consistency test for the conformation degree of the students' consciousness of one's own technological creativity, with the data being significant across all dimensions (Kolmogorov-Smirnov Z scores were 7.36***, 7.84***, 7.72***, 7.62*** and 7.44***, respectively). In the actual teaching situation, the conformation degree of all five aspects of the mechanical engineering students' technological creativity was consistent, with the mean being higher than 3.56.

A canonical correlation analysis for the conformation degree of mechanical engineering teachers' creative teaching and the conformation degree of mechanical engineering student's technological creativity was undertaken next.

Table 8 shows the results of the canonical correlation analysis. Between the conformation degrees of mechanical engineering teachers' creative teaching (X variable set) and the conformation degree of mechanical engineering student's technological creativity (Y variable set), it was found that one pair of canonical correlation reached the level of significance.

Table 8: Canonical correlation analysis for the conformation degree of mechanical engineering teachers' creative teaching and the conformation degree of the mechanical engineering students' technological creativity.

X Variable	Canonical Variable	Y variable	Canonical Variable
	χ_1		η_1
Characteristics of creative teaching	0.95	Specialised knowledge	0.84
Process of creative teaching	0.88	Sensitivity and quick response	0.78
Strategies for creative teaching	0.97	Skilful technique	0.82
		Positive attitude	0.79
		Perseverance	0.97
Variance explained (%)	87.06	Variance explained (%)	71.02
Redundancy (%)	61.48	Redundancy (%)	50.15
		ρ^2	0.71
		ρ	0.84
		Wilks' Λ	0.26***

***p<0.001; N=199

The canonical correlation coefficient (ρ) is 0.84 (Wilks' Λ=0.26***). It was found that 71.00% of the total variation of the Y variable set η1 canonical variable η1 can be explained by the X variable set χ1 canonical variable. It was also found that 71.02% of the total variation of Y variable set can be explained by its η1 canonical variable. The redundancy of the X variable set and the Y variable set is 50.15%. This means that, through the canonical variable (χ1, η1) path, 50.15% of the total variation of the Y variable set can be explained by the X variable set. The whole residual coefficient is 0.53, with Figure 1 showing the results.

Table 7: Consistency test for the conformation degree of the mechanical engineering student's technological creativity.

Dimension	N	Most extreme differences			Kolmogorov -Smirnov Z
		Absolute	Positive	Negative	
Specialised knowledge	1,393	0.20	0.17	-0.20	7.36 ***
Sensitivity and quick response	1,393	0.21	0.16	-0.21	7.84 ***
Skilful technique	1,393	0.21	0.17	-0.21	7.72 ***
Positive attitude	1,393	0.20	0.17	-0.20	7.62 ***
Perseverance	1,393	0.20	0.20	-0.19	7.44 ***
Whole	6,965	0.20	0.17	-0.20	16.67 ***

***p<0.001; N= Number of items x the effective sample counting

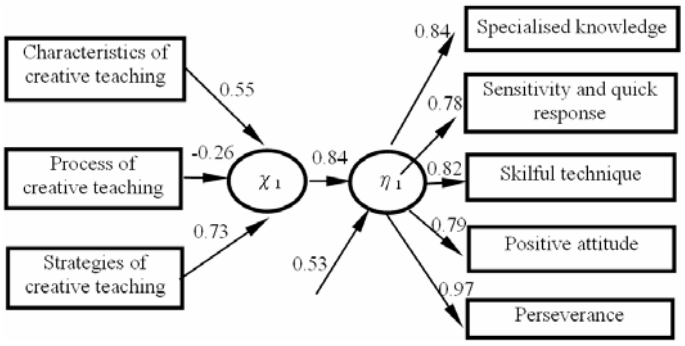

Figure 1: Canonical correlation path for the conformation degree of mechanical engineering teachers' creative teaching and the conformation degree of the mechanical engineering students' technological creativity.

So, through the canonical variable (χ1, η1) path, the conformation degree of the mechanical engineering students' technological creativity is influenced by the conformation degree of mechanical engineering teachers' creative teaching. When *strategies of creative teaching* for mechanical engineering teachers' creative teaching is higher (0.97), then the conformation degree of *perseverance* of the mechanical engineering students' technological creativity is higher (0.97).

CONCLUSIONS

This research is aimed at examining the actual conditions of mechanical engineering teachers' creative teaching and mechanical engineering students' technological creativity at vocational high schools in Taiwan, with the next target being to develop strategies to improve the situation. The above research and data analysis yielded the following conclusions:

- Mechanical engineering teachers' creative teaching includes three important elements, namely:
  - The characteristics of creative teaching;
  - The process of creative teaching;
  - The strategies of creative teaching.
- Mechanical engineering students' technical creativity includes five important elements, specifically:
  - Specialised knowledge;
  - Sensitivity and quick-response;
  - Skilful technique;
  - Positive attitude;
  - Perseverance.
- The actual conditions of mechanical engineering teachers' creative teaching only reached a *fair* degree. The mean of the whole consciousness of mechanical engineering students to teacher's creative teaching was 3.56. This indicated that the actual conditions of regarding mechanical engineering teachers' creative teaching are only of a *fair* degree. This needs to be advanced to *good*, *excellent*, *superior* and *outstanding*;
- The actual conditions of mechanical engineering students' technical creativity only reached a *good* degree. The mean of the whole conformation degree of mechanical engineering students' consciousness of one's own technological creativity was 3.81. As such, there is still considerable scope to develop and enhance this aspect;
- Each element of mechanical engineering teachers' creative teaching generates various influences on each element of students' technological creativity. This is because the different conformation degree of divided mechanical engineering teachers' creative teaching exerts different influences on students' technological creativity. For example, if the teachers' conformation degree in *the strategies for creative teaching* is high, then by the reciprocation of teaching, the degree of students' *perseverance* regarding their level of technological creativity is influenced and is also ranked as high.

SUGGESTIONS

By integrating the research analyses and conclusions, the author recommends the following suggestions:

- The application of mechanical engineering teachers' creative teaching still needs to be improved. This involves emphasising the application of creativity in teaching, enabling students to understand knowledge more deeply and become thoroughly familiar with technology, thereby positively influencing students' technological creativity;
- The current levels of mechanical engineering students' technological creativity need to be effectively advanced. As such, educational institutions should properly set up models and facilities in order to improve students' levels of technological creativity according to the needs of industry;
- This research tackles only the students' perspective, with future relevant research needing to be carried out on teachers' or industry viewpoints;
- The effective standardised survey instruments for technological creativity can be constructed in the future.

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