Original Research Article

Analysis of Factors Influencing Experimental Teaching Satisfaction Based on ISM-MICMAC

ABSTRACT

The satisfaction with experimental teaching is of utmost importance for improving educational quality, promoting student development, and fostering the professional growth of teachers. Researching the factors influencing satisfaction with experimental teaching, as well as the hierarchical relationships and mechanisms of action among these factors, provides significant theoretical foundations and practical guidance for conducting scientific and targeted reforms in experimental teaching.Based on literature research and questionnaire surveys, fifteen factors affecting experimental teaching satisfaction were selected across five dimensions: teachers, curriculum, students, environment, and interaction. The Interpretive Structural Modeling (ISM) was used to reveal the hierarchical relationships among these factors, and the Cross-Impact Matrix Multiplication Applied to a Classification (MICMAC) method was employed to validate the model's scientific validity and assess the driving forces and dependencies of each factor.The research results indicate that self-efficacy, academic emotions, perceived course value, teacher-student interaction, and peer interaction are direct factors influencing experimental teaching satisfaction and exhibit a high level of interdependence. Teacher's teaching competence, laboratory management, course content, course resources, and laboratory environment are deeper influencing factors with strong driving forces, positively impacting both the direct factors and intermediary factors such as teaching models and course assessment. Based on the analysis results, improvement strategies, and recommendations are proposed to enhance the quality of experimental teaching and the effectiveness of talent development.

Keywords: Teaching satisfaction;Experimental teaching; ISM; MICMAC; Factors analysis

INTRODUCTION

High-quality development is the lifeline of higher education, and teaching satisfaction is an important indicator for measuring the quality of education. The report of the 20th National Congress of the Communist Party of China pointed out that providing education that satisfies the people is an important support for implementing the strategy of invigorating China through science and education and developing a strong workforce for the modernization drive. In *the Implementation Plan for the Evaluation and Assessment of Undergraduate Education in Higher Education Institutions (2021-2025)* released by the Ministry of Education, the evaluation index system states that "student satisfaction with learning and personal growth" will be used as an important indicator for measuring the effectiveness of university education. Experimental teaching is a crucial component in nurturing students' practical and innovative abilities,[1].Therefore, studying the influencing factors and mechanisms of undergraduates' experimental teaching satisfaction has practical guiding significance for improving the quality of experimental teaching, enhancing students' comprehensive qualities, and promoting high-quality development in higher education.

1. LITERATURE REVIEW

In the education field of China, the widely accepted and adopted interpretation of "teaching" is considered a bilateral activity involving both "teaching" and "learning", emphasizing the unity of teaching and learning,[2]. The concept of teaching satisfaction is derived from customer satisfaction theory,[3], with an important viewpoint being that education is a product, and students are the consumers of this product; in the process of "consumption", the product's value influences students' satisfaction and their willingness to continue learning; teaching satisfaction reflects learner's experience and the degree to which their learning expectations are met. Student satisfaction with experimental teaching assesses the difference between the learning outcomes and learning expectations during the teaching process. It is one of the indicators for evaluating the effectiveness of experimental teaching,[4].Deng Ping'an (2015) demonstrated through empirical research that teaching content and teaching attitudes are the main factors influencing student satisfaction,[5].Yu Huai and Huang Yan's research (2023) indicates that teaching methods, attitudes, teaching proficiency, and textbook selection significantly influence the satisfaction levels of university students,[6]. Xiong Huajun's (2013) study, using a multiple-group structural equation model, indicates that satisfaction with teaching resources, teaching process, teaching management, teaching objectives, and pedagogical scholarship differs among students of different grades, genders, and majors,[7]. Li Dan (2013), through empirical research, has shown that student engagement in teaching, teacher competence, students' learning attitudes, and the experimental environment all significantly influence satisfaction with experimental teaching,[8]. Gao Jiangjiang and others (2018) have researched virtual experiment learning satisfaction in the MOOC (Massive Open Online Course) environment and found it closely related to factors such as the appropriateness of experimental content design, the flexibility of experimental operations, the intuitiveness of experimental operations, aiding learners in understanding and acquiring knowledge, stimulating learner interest, the interaction frequency between learners and teachers, and time management skills,[9]. Li Xian (2019) collected data through questionnaires and conducted empirical research using the Logistic model. It was found that teacher factors, student factors, and environmental factors are important factors influencing the satisfaction of college students with English teaching,[10]. Zhu Liancai and others (2020), based on the perspective of students' teaching experiences, surveyed the satisfaction of learning in large-scale online open teaching. They proposed that the fundamental reasons affecting students' satisfaction with online learning lie in learning objectives, teacher-student interaction, and teacher attention to student progress,[11]. Zhang Xueyan and others (2020), using open-education learners as their research subjects, employed the structural model to conduct research and found that student self-efficacy, academic emotions, and teacher-student interaction are important factors influencing online teaching satisfaction,[12]. Li Mengxuan and others (2022), based on satisfaction theory and through empirical research, discovered that optimizing teaching content, establishing case resource libraries, launching interaction between teachers, students, and computers, and conducting developing experiments are significant for enhancing students' perception of the quality of experimental teaching, thereby providing essential importance for the satisfaction of students majoring in engineering management,[13].

As seen above, most of the existing research currently focuses on revealing the positive and negative impacts of various subjective and objective factors on satisfaction. However, there is a lack of research on the hierarchical structure and interaction mechanisms between these factors. The theoretical basis of the research largely relies on customer satisfaction theory, while overlooking the systematic nature of teaching and the differences between the teaching process and the consumption process. This study intends to use a combination of statistical analysis and systems engineering methods to establish an ISM hierarchy model of factors influencing experimental teaching satisfaction. The model's validity will be verified using the MICMAC method, aiming to reveal the hierarchical relationships and driving-dependency relationships between these factors. Based on the analysis results, this study will propose improvement strategies and recommendations to enhance the quality of experimental teaching and the effectiveness of talent development.

2. RESEARCH METHODS AND FRAMEWORK

2.1 RESEARCH METHODS

2.1.1 Interpretive Structural Model

Interpretive Structural Modeling, abbreviated as ISM, uses two-dimensional matrix mathematical operations to construct an intuitive multi-level structural model by connecting related factors using directed edges. It can transform the complex and abstract relationships among various system factors into visual graphics, making it easier to analyze the compositional relationships between factors in complex systems and study the positions and roles of factors within the system.

The modeling steps of the ISM are as follows: establish goals and identify system factors; experts analyze the degree of correlation between elements based on their systematic knowledge and practical experience, and assign scores to determine the adjacency matrix A; calculate the reachability matrix M based on the adjacency matrix A; partition the reachability matrix M into levels and obtain a reduced reachability matrix M1 through the sorted reachability matrix M0; draw the Interpretive Structural Model diagram based on the reachability matrix M1.

2.1.2 Cross-Impact Matrix Multiplication Applied to Classification

Cross-Impact Matrix Multiplication Applied to Classification (MICMAC) is a method that uses the reachability matrix obtained in the ISM model and determines the driving forces and dependencies of factors in the system based on matrix multiplication principles, analyzes the impact and dependency relationships between various factors in the system, and clarifies the status and roles of each factor. The results of the MICMAC method are represented on a two-dimensional coordinate system with driving forces on the vertical axis and dependencies on the horizontal axis. Each factor is categorized into the corresponding quadrant based on its dependency and driving force. The coordinate system is divided into four quadrants as follows: Quadrant I corresponds to the autonomous factor group, Quadrant II corresponds to the dependent factor group, Quadrant III corresponds to the linkage factor group, and Quadrant IV corresponds to the independent factor group. The combination of the MICMAC method and the ISM model serves a dual purpose. On one hand, it helps identify the direct factors, intermediate factors, foundational factors, and root factors influencing experimental teaching satisfaction. This aids in pinpointing the critical factors that require focused management and intervention. On the other hand, it allows for the mutual validation of MICMAC results and the ISM model, ensuring the accuracy and consistency of the model outcomes.

2.2 RESEARCH FRAMEWORK

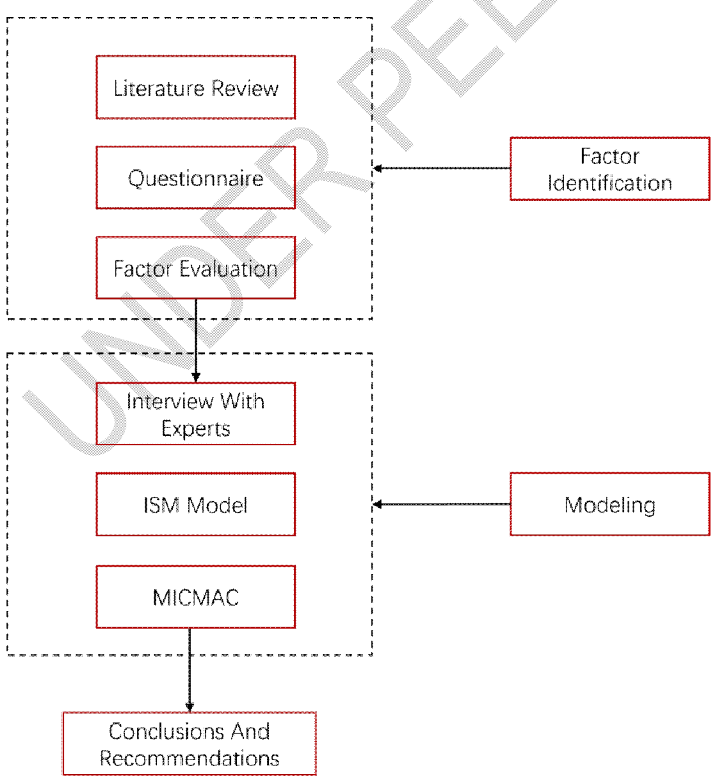

Fig.1. Research Framework

3. SELECTION AND EVALUATION OF FACTORS AFFECTING SATISFA CTION

3.1 FACTORS SELECTION

Schwab proposed that there are four major elements influencing course implementation, which include teachers, students, teaching content, and the teaching environment,[14]. Based on this theory and combining it with literature research, factors with different expressions but similar meanings were extracted and integrated and expert opinions were sought. Ultimately, 15 influencing factors were selected from five dimensions: teachers, students, curriculum, environment, and interaction, as shown in Table 1.

Table 1. Factors Affecting Experimental Teaching Satisfaction

Dimensions	Influencing Factors	Code	Explanations of Factor Connotation
Students	Self-Efficacy	F_1	The degree of students' confidence in their ability to complete course learning tasks, such as their confidence in facing and overcoming difficulties or obstacles encountered during the learning process of experimental courses, and their ability to express themselves and communicate confidently,[15].
	Academic Emotions	F_2	Emotions directly related to the learning process and outcomes, including joy, excitement, boredom, frustration, and anxiety, etc,[16].
	Perceived Course Value	F_3	Perceiving that experimental teaching enhances problem-solving, teamwork, professional competence, and contributes to employment, further education, and lifelong development,[17,18]
Teachers	Teaching Attitudes	F_4	Teachers' attitude towards students and teaching activities as reflected in whether the teacher provides patient experimental guidance, diligently corrects and provides feedback on experiment reports, etc,[**Error! Bookmark not defined.**].
	Teaching Abilities	F_5	Teachers' professional knowledge, student abilities, research skills, and comprehensive teaching skills,[**Error! Bookmark not defined.**,19,20].
	Individual Styles	F_6	Teachers' language style, personality traits and charm,[21].
Cours	Course Content	F_7	Experimental teaching content reflects

es			professional features, includes diverse cases, and is closely linked to theory ,[**Error! Bookmark not defined.**,**Error! Bookmark not defined.**].
	Teaching Modes	F_8	Using technologies and methods such as the Internet, and big data, to implement flipped classrooms, blended learning, virtual experiments, and simulation experiments ,[**Error! Bookmark not defined.**,22,23].
	Evaluation And Assessment	F_9	Adopted evaluation methods and courses have clear assessment criteria and fair and reasonable evaluation ,[24,**Error! Bookmark not defined.**].
	Course Resources	F_{10}	Availability of experimental guides, help manuals, and personalized learning resources '[**Error! Bookmark not defined.**,**Error! Bookmark not defined.**].
	Laboratory Environment	F_{11}	Reasonable Layout, well-equipped, and tidy experimental teaching sites ,[**Error! Bookmark not defined.**].
Environments	Teaching Software, Platforms, And Instruments	F_{12}	Experimental environment is built aligned with experimental content, condition and performance of experimental instruments and equipment,[25,26].
	Laboratory Management	F_{13}	Providing open experimental opportunities, and student-friendly management ,[**Error! Bookmark not defined.**].
Interaction	Teacher-Student Interaction	F_{14}	Communication and interaction between teachers and students on experiment content, both online and offline, during or after experimental teaching, [**Error! Bookmark not defined.**].
	Student-Student Interaction	F_{15}	Communication and interaction among students on experiment content, both online and offline, during or after experimental teaching, [**Error! Bookmark not defined.**].

3.2 FACTORS EVALUATION

To ensure the reliability of the factors influencing experimental teaching satisfaction, the study further used the Likert scale to assess the factors listed in Table 1.

3.2.1 Questionnaire Design

Based on the initial determination of factors, a questionnaire on the factors influencing experimental teaching satisfaction was designed. The questionnaire consists of two parts: basic information about the respondents and a measurement scale comprising 15 factors that influence experimental teaching satisfaction. The survey data are scored using the Likert five-point scale method. “Very Dissatisfied” is scored as 1 point, “Dissatisfied” as 2 points, “Satisfied” as 3 points, “Quite Satisfied” as 4 points, and “Very Satisfied” as 5 points.

3.2.2 Questionnaire Overview

Between July 2, 2022, and December 30, 2022, an online survey was conducted on students majoring in science and engineering at three undergraduate colleges in Yancheng, Jiangsu, and Handan, Hebei. A total of 516 survey questionnaires were received, after excluding invalid questionnaires with excessively short completion times, logical contradictions in responses, and responses indicating “Very Satisfied” for all questions, the final number of valid questionnaires was 504. Descriptive statistical analysis of the questionnaires revealed that the gender distribution was 50.5% male and 49.5% female. Regarding the academic year of the respondents, 31.1% were freshmen (Year 1), 26.6% were sophomores (Year 2), 25.6% were juniors (Year 3), and 16.7% were seniors (Year 4). The students belonged to a total of 11 majors across the three institutions, with the top three major categories being Computer Science at 20.6%, Mechanical Design and Manufacturing at 16.4%, and Chemical Engineering at 10.5%.

3.2.3 Exploratory Factors Analysis

The questionnaire underwent reliability and validity testing by SPSS PRO software. The Cronbach’s α coefficient was 0.97, indicating the high reliability of the questionnaire. The validity coefficient, KMO, was 0.93, suggesting good overlap among the variables. The significance level of Bartlett’s Test of Sphericity was 0.000, indicating extreme significance, which means that the data is suitable for factor analysis. Through principal component factor analysis, all factors loading coefficients were greater than 0.5, indicating the high structural validity of the questionnaire. Factors with eigenvalues greater than 1 were selected and the total variance explained was 75.42%, showing that the selected factors effectively represent the information of each variable.

4. ISM OF FACTORS AFFECTING EXPERIMENTAL TEACHING SATISFACTION

4.1 ESTABLISHMENT OF THE ADJACENCY MATRIX

To determine whether there was a correlation between different factors, this correlation was represented with binary logical values in the form of an adjacency matrix, denoted as A=[Fij] (i, j=1,2,3...,15), where Fij signifies the relationships between different factors. To minimize the influence of expert bias and subjectivity on the final results, seven teachers with associate professor or higher academic titles, who had extensive experience in experimental teaching, were invited to assess the relationships between the 15 factors. If more than half of the experts considered that factor Fi had an impact on factor Fj, then Fij=1; otherwise, if the experts believed that factor Fi had no impact on factor Fj, then Fij=0. In cases where expert opinions were similar, the ISM team, combining the experts' opinions, determined the influence relationship of factor Fi on Fj. Using the aforementioned method, the obtained adjacency matrix is shown in Figure 2.

$$A = \begin{bmatrix}
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\
1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
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1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}$$

Fig.2. Adjacency Matrix A

4.2 CALCULATION OF THE REACHABILITY MATRIX

The adjacency matrix only represents direct influence relationships between F1 to F15. To determine both the direct and indirect influence relationships among factors and their transitivity, it is necessary to generate the reachability matrix. The specific al
gorithm for the reachability matrix is as follows: when the adjacency matrix A satisfies

$$M = \begin{bmatrix}
1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\
1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\
1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\
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1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 \\
1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 \\
1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1
\end{bmatrix}$$

$(A+1)^{n-1} \neq (A+1)^{n} = (A+1)^{n+1} = M (n=1,2,...)$, then M is the reachability matrix, where the matrix I is the identity matrix. The reachability matrix M was obtained using MATLAB, as shown in Figure 3.

Fig.3.The Reachability Matrix M

4.3 HIERARCHICAL DIVISION

In the reachability matrix, the elements in the F_i row, which are all 1, correspond to the reachable set $R(F_i)$ of the influencing factor F_i. The elements in the F_i column of the reachability matrix, which are all 1, correspond to the precedent set $Q(F_i)$ of the influencing factor F_i. If $R(F_i) \cap Q(F_i) = R(F_i)$, then the factors in $R(F_i)$ belong to the first layer of the hierarchy. After removing the first layer, the rows and columns corresponding to the elements in the first layer of the reachability matrix are deleted, and this process is repeated until the hierarchical level of each factor in the system is determined. Following the above steps, the 15 factors are divided into four layers: the first layer includes F_1, F_2, F_3, F_{14}, F_{15}; the second layer includes F_4, F_8, F_9; the third layer includes F_6, F_7, F_{10}, F_{11}, F_{12}; and the fourth layer includes F_5, F_{13}.

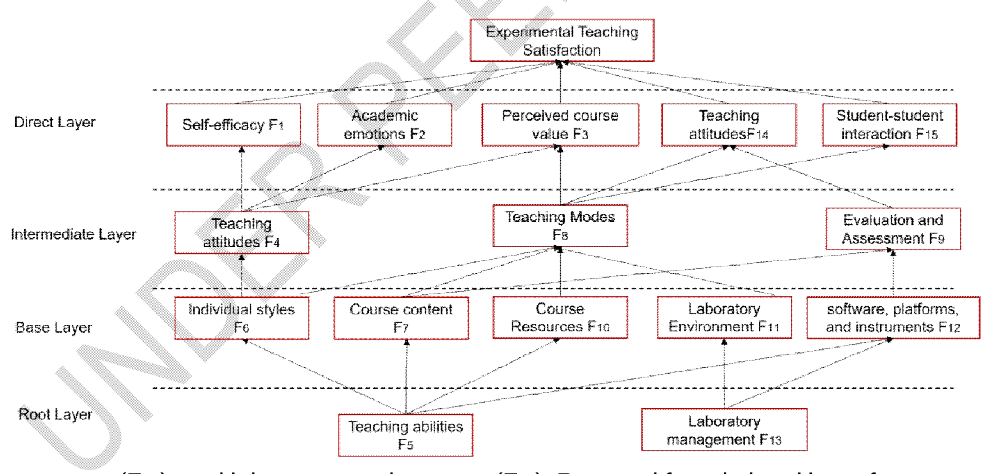
Table 2. the Reachable Sets and Precedent Sets in the Reachability Matrix.

No	the Reachable SetsR（Fi）	the Precedent Sets $Q(F_i)$	the Intersection $R(F_i) \cap Q(F_i)$
F_1	1, 2, 3, 14, 15	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15	1, 2, 3, 14, 15
F_2	1, 2, 3, 14, 15	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15	1, 2, 3, 14, 15
F_3	1, 2, 3, 14, 15	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15	1, 2, 3, 14, 15
F_4	1, 2, 3, 4, 14, 15	4, 5, 6, 7, 10, 11, 12, 13	4
F_5	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15	5	5
F_6	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15	5, 6, 7, 10, 11, 12, 13	6, 7, 10, 11, 12
F_7	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15	5, 6, 7, 10, 11, 12, 13	6, 7, 10, 11, 12
F_8	1, 2, 3, 8, 14, 15	5, 6, 7, 8, 10, 11, 12, 13	8
F_9	1, 2, 3, 9, 14, 15	5, 6, 7, 9, 10, 11, 12, 13	9
F_{10}	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15	5, 6, 7, 10, 11, 12, 13	6, 7, 10, 11, 12

F_{11}	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15	5, 6, 7, 10, 11, 12, 13	6, 7, 10, 11, 12
F_{12}	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 14, 15	5, 6, 7, 10, 11, 12, 13	6, 7, 10, 11, 12
F_{13}	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15	13	13
F_{14}	1, 2, 3, 14, 15	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15	1, 2, 3, 14, 15
F_{15}	1, 2, 3, 14, 15	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15	1, 2, 3, 14, 15

4.4 ISM ANALYSIS OF FACTORS AFFECTING EXPERIMENTAL TEACHING SATISFACTION

Based on the results of hierarchical division and to ensure the simplicity and readability of the model, the influence relationships between factors across different layers were ignored, and an Interpretive Structural Model was constructed. According to the relationships between system factors, the first layer represents direct factors, the second layer, intermediate factors, the third layer, foundational factors, and the fourth layer, root factors. Root factors include teaching proficiency (F_5) and laboratory management (F_{13}). Foundational factors include personal style (F_6), teaching content (F_7), teaching



resources (F_{10}), and laboratory environment (F_{11}). Root and foundational layer factors are the deep-seated factors influencing experimental teaching, with the most significant impact and the most obvious effects. Intermediate layer factors include teaching attitude (F_4), teaching mode (F_8), and assessment (F_9), which play a bridging role, having relationships of influencing and being influenced. Direct factors include self-efficacy (F_1), academic emotions (F_2), perceived course value (F_3), teacher-student interaction (F_{14}), and student-student interaction (F_{15}). These factors need to exert their influence through intermediate and foundational factors and are the most direct factors affecting experimental teaching satisfaction, as shown in Figure 4.

Fig. 4. ISM of Experimental Teaching Satisfaction

5. MICMAC ANALYSIS OF FACTORS AFFECTING EXPERIMENTAL TEACHING SATISFACTION

The MICMAC model is calculated based on the reachability matrix M. The driving force is the number of elements with a value of 1 in the row of each factor in M, while the dependency is the number of elements with a value of 1 in the column corresponding to each factor in M. The numerical values of the driving force and dependency of influencing factors are shown in Table 3, and the classification of the driving force and dependency of influencing factors is illustrated in Figure 5.

In the ISM, most factors are categorized as independent, dependent, and autonomous factors, with no linkage factors. This indicates that the selected factors are representative, and the system exhibits good stability.

(1) In the ISM, factors from the foundational and root layers are located in the fourth quadrant, forming an independent factor group. This group includes teaching proficiency (F_5), personal style (F_6), course content (F_7), laboratory environment (F_{11}), course resources (F_{10}), experimental software platforms and instruments (F_{12}), and laboratory management (F_{13}). These factors not only have high driving forces but also have a broad scope of influence, affecting other factors to some extent. Such factors play a critically important role in determining experimental teaching satisfaction.

(2)Factors in the direct layer of the ISM are all located in the second quadrant, forming a dependent factor group. This group includes self-efficacy (F_1), academic emotions (F_2), perceived course value (F_3), teacher-student interaction (F_{14}), and student-student interaction (F_{15}). They are the most direct and top-level factors affecting experimental teaching satisfaction, influenced significantly by lower-level factors in the system. They have low driving forces but high dependency.

(3)Intermediate layer factors in the ISM, including teaching attitude (F_4), teaching mode (F_8), and assessment (F_9), are located in the first quadrant, forming an autonomous factor group. Autonomous factors have relatively low driving forces and dependencies, resulting in a smaller overall impact on the system. They play a bridging role and require coordinated control among various factors.

(4)The third quadrant is a linkage group of independent and dependent factors with lower stability and prone to influence the system. As seen in Figure 5, there are no linkage factors in the system, indicating that there are no strong interactions or counteractions between factors. The selection of factors exhibits good stability.

Table 3. The Driving Force and Dependency of Influencing Factors

Influencing factors	Driving force	Dependency	Influencing factors	Driving force	Dependency
F_1	15	5	F_9	8	7

F_2	15	5	F_{10}	3	11
F_3	15	5	F_{11}	1	13
F_4	5	6	F_{12}	2	11
F_5	1	10	F_{13}	1	12
F_6	7	9	F_{14}	15	5
F_7	7	9	F_{15}	15	5
F_8	9	6			

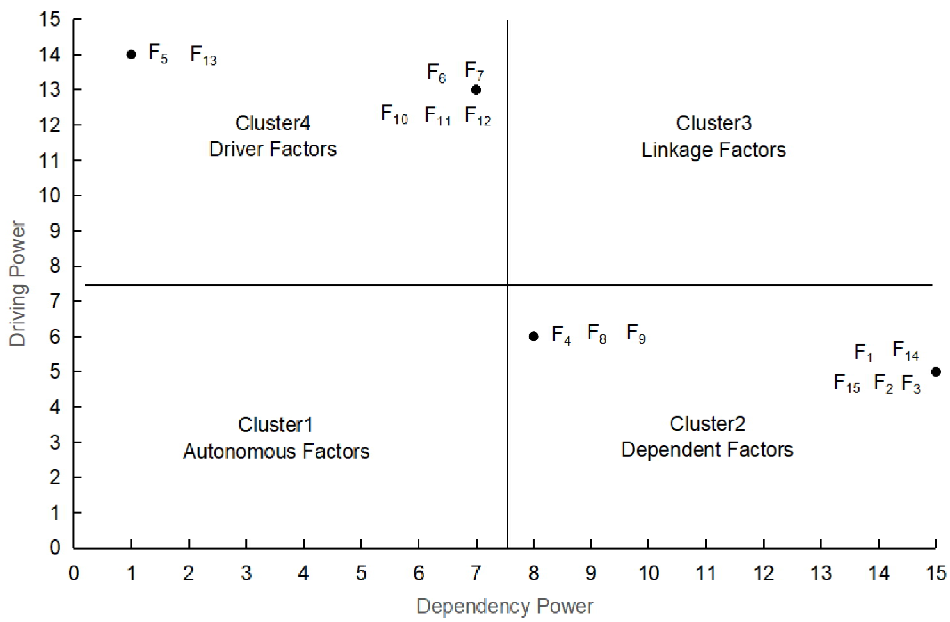


Fig.5. MICMAC Model of Factors Affecting Experimental Teaching Satisfaction

6. RECOMMENDATIONS AND SUGGESTIONS

Based on the ISM-MICMAC analysis results of factors affecting experimental teaching satisfaction, the following recommendations and suggestions are proposed for experimental teaching.

6.1 ENHANCE TEACHERS' TEACHING ABILITIES, UPGRADE TEACHING CONTENT, IMPROVE LABORATORY CONSTRUCTION AND MANAGEMENT, AND PREVENT THE 'SHORTCOMING EFFECT'

Experimentation is the foundation of innovation. Experimental teaching has its unique requirements. On the one hand, it should be tailored to the school's orientation, the goals of talent development, and the specific conditions of the school's laboratories. Experimental projects should be set up according to specific needs. On the other hand, On the other hand, teachers need to have a high level of experimental teaching skills, demonstration and operational abilities, and, even more importantly, they should possess innovative practical skills guided by theory. Experimental instructors should, based on the characteristics of the experiments, restructure the experimental practice system and establish outcome-oriented, task-driven, project-based practical teaching. This is an important way to stimulate students' motivation to learn, enhance their sense of accomplishment, and foster a sense of achievement.

Harnessing the advantages of new information technologies such as big data, artificial intelligence, and virtual reality has provided an intelligent and integrated experimental environment for current experimental teaching.On the one hand, well-equipped laboratories for smart experimental teaching in an Internet+ environment should be established. In addition to real-time recording of students' experimental processes, observations, and results, they can also analyze students' practical behaviors, achieving a more process-oriented, diverse, and precise evaluation of experimental teaching.On the other hand, schools at all levels can develop virtual simulation experiments, providing students with an open and user-friendly virtual simulation environment. Students can conduct simulated experiments in an organized, standardized, safe, and cost-effective manner. Subsequently, these experiments can be validated through experiments, making experimental teaching more efficient. Schools can also engage in deep collaboration with businesses, establishing collaborative innovation laboratories between educational institutions and enterprises. This facilitates the cultivation of practical talents aligned with industry and corporate needs, enhancing students' professional abilities and professionalism.

6.2 WITH STUDENTS AS THE CENTER, SCHOOLS SHOULD IGNITE THEIR MOTIVATIONS, ENHANCING THEIR EFFICIENCY, AND LEVERAGING THE SYNERGY BETWEEN TEACHERS AND STUDENTS.

The key is to enhance the satisfaction with experimental teaching, and students should be placed in the center of teaching.Student self-efficacy, academic emotions, and perceived course value are subjective experiences and are also influenced by external factors.

First, we should establish the concept of well-rounded education with emphasizes on three key dimensions: moral education, intellectual education and physical education. Teachers, staff responsible for student affairs, and laboratory management personnel should closely collaborate to concern, understand students' psychological conditions, promptly relieve and regulate their mental and emotional issues, address their difficulties in learning and life, provide emotional support and encouragement, and help them maintain a positive state in academic emotions.

Second, experimental teaching is the process where students apply theoretical knowledge in practical experiments to test and discover knowledge and enhance their professional knowledge and skills. Teachers, based on the prerequisites of "higher-level, innovation, and challenge" in practical courses, gradually increase the complexity of problem-solving and experiments. Through continuous progression, students' self-efficacy is enhanced.

Third, teachers should adopt a variety of teaching methods flexibly during the teaching process, create scenarios and tasks, stimulate students' enthusiasm and motivation for learning, focus on outcomes, and enhance students' perception of the value of curriculum learning.Teachers should, based on their flexible command of teaching modes and experimental forms, actively interact and collaborate with students, and accurately and efficiently address the issues encountered by students during the experimental process.At the same time, students should be encouraged to collaborate and communicate with each other, especially through rational grouping based on the actual needs of experimental teaching and differences in students' abilities, learning styles, and more. This allows students to engage in effective interaction during the process, leveraging each other's strengths and making progress together.

6.3 ADOPT A SYSTEMS PERSPECTIVE AND EMPHASIZE THE "MULTIPLIER EFFECT" OF FACTORS

The ISM illustrates the interrelationships among factors influencing experimental teaching satisfaction. These factors are not independently present in the system but interact and coordinate with each other.From a systems theory perspective, numerous factors can form clusters of influencing factors. These clusters can have different combinations at different stages, resulting in varying effects on teaching satisfaction. The superposition of influencing factors will amplify the impact of a single factor, creating a multiplier effect, which significantly affects the effectiveness and quality of experimental teaching.When combining the ISM and the MICMAC model, and formulating measures to enhance the quality and effectiveness of experimental teaching and promote teaching satisfaction, the following points should be taken into consideration:

First, a thorough understanding of the systemic nature of experimental teaching satisfaction is essential. It is necessary to adopt a systems theory perspective and take appropriate measures for all dimensions of influencing factors involved, enabling systematic management.

Second, when formulating measures to enhance the quality and effectiveness of experimental teaching and improve teaching satisfaction, it is imperative to dispel one-sided perspectives in teaching management and operations, bridge the gap between theory and practice, and address issues such as grade inflation and disparities in ability. Factors at the root, intermediate, and surface levels that contribute to the current situation should be thoroughly assessed, and management strategies should take a comprehensive and curative approach.

Third, the degree and hierarchy of the impact of various factors may change due to differences in majors, courses, and individual students, especially as students progress from their first year to their fourth year, improving their professional knowledge, self-awareness, and learning abilities. The extent and relationships of the factors will evolve. It is important to establish a mindset of continuous improvement and dynamically manage the factors influencing experimental teaching satisfaction.

7. CONCLUSION

This paper applied the ISM-MICMAC to analyze the factors influencing experimental teaching satisfaction. It revealed the logical hierarchical relationships and driver-dependency relationships among these factors. Based on this analysis, it has proposed desirable strategies and recommendations, which serve as references for enhancing the quality of experimental teaching. When establishing the ISM, the adjacency matrix was determined by expert ratings, and it’s important to note that individual and subjective factors of the experts may have had some influence on the results.

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