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Evaluation of Usability for Interdisciplinary Teaching Module for Enhancement of High-order Thinking Skills Among College Educators

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Abstract: The main purpose of this study was to evaluate an interdisciplinary teaching module (IHTM) that had been developed, and this evaluation determined the usability of the module and its instructional objectives in strengthening the higher-order thinking skills of Chinese university students. The evaluation process involved a total of 37 teachers in interdisciplinary fields; these participants included 27 young teachers and 10 expert teachers. Descriptive analyses, comparative analyses, and Fuzzy Delphi (FDM)-based expert consensus were used to derive results in terms of the module's usability. Findings indicated the module's usability and usefulness in strengthening higher-order thinking skills, and the 10-member expert panel reached a consensus on the evaluation of the module's usability.

Keywords: Usability, interdisciplinary teaching, university, high-order thinking skills, Fuzzy Delphi Method (FDM)

1. Introduction

Interdisciplinary teaching and learning in universities have become increasingly important in fostering a holistic educational environment. This approach encourages the integration of multiple disciplines, allowing students to draw connections between diverse fields of study, thereby enhancing their critical thinking and problem-solving skills. Research has shown that interdisciplinary education not only enriches students' academic experiences but also prepares them for the complexities of the modern workforce, which often requires a blend of skills and knowledge from various domains (Rafiq et al., 2024). Furthermore, interdisciplinary curricula can promote innovation and creativity by encouraging students to explore and synthesize different perspectives (Repko et al., 2020). By breaking down traditional academic silos, universities can create a more dynamic and engaging learning environment that reflects the interconnected nature of real-world issues (Klein, 2018).

High-order thinking skills (HOTS) are crucial in university education as they foster deeper understanding and intellectual development among students. HOTS encompass critical thinking, problem-solving, analysis, synthesis, and evaluation, allowing students to navigate complex information, make reasoned judgments, and innovate solutions to intricate problems. According to recent research, the integration of HOTS in university curricula significantly enhances students' cognitive abilities, better preparing them for the multifaceted demands of the modern workforce (Ahmad, 2020). Emphasizing HOTS in higher education also promotes a more engaged and active learning process. Students transition from being passive recipients of information to becoming active participants in their educational journey, which cultivates a deeper connection with the material and a more profound understanding of their subjects (Nykyporets et al., 2023). Moreover, the focus on HOTS encourages lifelong learning by equipping students with the skills necessary to adapt and thrive in a rapidly changing world. By nurturing these skills, universities can create a learning environment that not only imparts knowledge but also fosters innovation, adaptability, and critical engagement, ensuring that students are well-equipped for professional success and informed citizenship (Sujatha & Sangeetha, 2023).

Interdisciplinary teaching and learning have been recognized for their significant benefits in enhancing student engagement, higher-order cognitive skills, and real-world problem-solving capabilities. However, in Chinese universities, the implementation of interdisciplinary education faces notable challenges. Despite the global trend towards integrating multiple disciplines to foster critical thinking, creativity, and strategic problem-solving, Chinese university students appear to lag in these areas. Research has shown that Chinese college students exhibit minimal gains in critical thinking skills after four years of tertiary education (Liu et al., 2021). This deficiency is often attributed to the predominant reliance

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on rote learning and the lack of pedagogical environments that encourage critical and creative thinking (Guan, 2021). Fig. 1 shows the model that has been developed and evaluated.

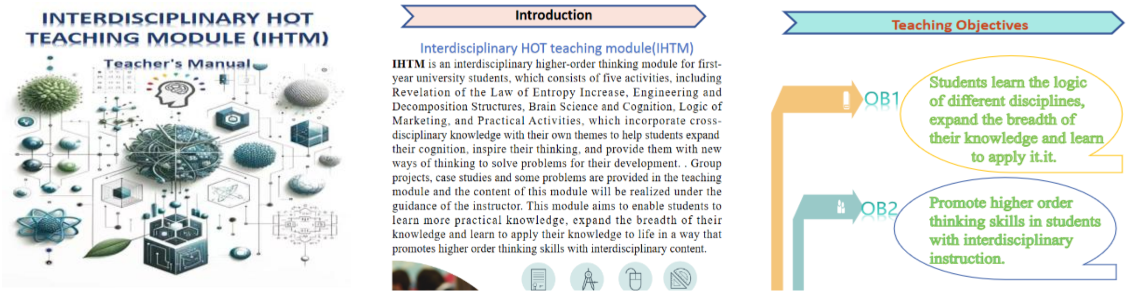

Fig. 1. The model that has been developed and evaluated

Furthermore, quantitative assessments indicate a decline in higher-order thinking abilities among Chinese student post-admission, highlighting the urgent need for educational reform (Yu, 2019). Enhancing interdisciplinary teaching in Chinese universities could address these gaps by fostering better student motivation, engagement, and cognitive development. It is imperative to explore effective strategies for integrating interdisciplinary approaches within the Chinese higher education system to cultivate a more holistic and adaptable skill set among students (Huo & Han, 2024). The main purpose of this study was to evaluate the interdisciplinary teaching module that has been developed, and this evaluation determined the usability of the teaching module and its instructional role in reinforcing the higher-order thinking (HOTS) skills of Chinese university students. Therefore, an evaluation method for the usability and effectiveness of the module in terms of HOTS was designed and the results of the analysis are presented. There are two research questions that need to be answered to meet this study purposes which are:

1) What is the interdisciplinary teacher evaluation of the usability of this teaching module?
2) What is the consensus of the expert panel on the usability and effectiveness of this interdisciplinary HOTS module?

2. Methodology

To evaluate the usability and effectiveness of the interdisciplinary Higher Order Thinking (HOT) teaching module (IHTM), a comprehensive evaluation was conducted following its development in this study. The evaluative process utilized a structured questionnaire, enabling the determination of the module's usability and effectiveness through quantitative analysis of the collected statistical data.

2.1 General Statistics

By using SPSS V26, all items of questionnaire were subjected to general descriptive statistics including mean, frequency and standard deviation, and overall values under each structure were calculated to evaluate the usability of IHTM under these five structures, and the cut-off point method (Yusof et al., 2015) was used for the evaluation criteria. The measure of teaching module usability in this study was interpreted using descriptive analyses based on mean score values, and standard deviation for each item. The results of the mean scores were categorized into low, medium and high usability levels. Data were categorized using a five Likert scale with a minimum score of 1 and a maximum score of 5. Availability means between 1 and 2.33 are considered low usability, means between 2.34 and 3.67 are considered medium usability, and means between 3.68 and 5.0 are considered high usability. A cut-off point method was used for this availability (Yusof et al., 2015).

2.2 Fuzzy Delphi Method (FDM)

The fuzzy Delphi method (FDM) evaluation approach was applied to the study of instructional design and development to derive the level of respondent consensus on teaching module (Gengatharan et al., 2023). As the participants included a group of 10 expert teachers, which fulfils the requirement for an expert consensus panel size, as Ocampo et al. (2018) suggest a range of 10 - 15 experts in the expert consensus method. The fuzzy Delphi analysis template (FDMv2. 0) proposed by Ridhuan et al. (2024) was employed in the progress of achieving consensus. The evolution of innovation on the development of Fuzzy Delphi Analysis Template or known as FDMv2.0 which has been developed since 2013 as well as through the process of innovation in ensuring the generation of data findings for FDM methods can be implemented well and effectively. Thus, the FDMv2.0 analysis template that has been developed has also been widely used in areas such as pedagogical development. The following description shows the statistical and analytical process of this template. At first, determining the linguistic scale, the linguistic scale is a Likert scale with addition of fuzzy numbers (Hsieh et al., 2004). It is mainly used to solve the problem of ambiguity of expert's opinion about items and includes three values as shown in Fig. 2, Where ml is the smallest value: m2 is the most plausible value; m3 is the largest value.

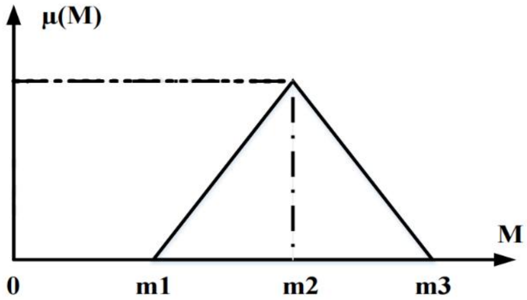

Fig. 2. Triangular Fuzzy number

Since the Teaching Module Usability Questionnaire is a 5-point Likert scale. So, for every response there will be three values as in Table 1.

Table 1. Fuzzy scale for 5-point Likert

	Likert scale	Fuzzy scale		
Strongly agree	5	0.75	1.00	1.00
Agree	4	0.50	0.75	1.00
Moderately agree	3	0.25	0.50	0.75
Disagree	2	0.00	0.25	0.50
Strongly disagree	1	0.00	0.00	0.25

The average fuzzy number M value about each item is calculated by the Formula 1, which is the synthesis value of the scores assigned by the panel of experts about the same item.

$$M = \frac{\sum_{i}^{n}=1 \text{ mi}}{\text{n}} \quad (1)$$

After completing the calculation of the M-value, in order to derive the consensus of the experts about an ITEM, the d-value is introduced and the calculation is shown in the following equation, which indicates the degree of dispersion of the expert group from the composite M-value, i.e., it illustrates the degree of consensus.

$$d\left(\acute{M}, \acute{m}\right) = \sqrt{\frac{1}{3}}\ [(M1 - m1)^{2} + (M2 - m2)^{2} + (M3 - m3)^{2}] \quad (2)$$

According to Chang et al. (2011) the experts are considered to have achieved a consensuse if the threshold value is less than or equal to 0.2 and the overall group consensus should be more than 75%, otherwise the survey should be repeated until consensus achieved. Subsequently, it is necessary to Identifying alpha-cut level, since the triangular fuzzy values transformed by the 5-level Likert scale are between 0 and 1, the alpha-cut values used for evaluating fuzzy evaluations are also between 0 and 1. based on the previous literature (Saido et al., 2018; Abdelgawad & Fayek, 2010), the alpha-cut (0.5) was used as a cut level. The acceptance of the IHTM validity description was determined by comparing the alpha-cut with the Fuzzy Score, i.e., an item with a fuzzy score greater than 0.5 was considered to have reached an expert consensus, and the formula for calculating the Fuzzy Score is shown below.

$$A = 1/3 * (m1 + m2 + m3) \quad (3)$$

Meanwhile, the size of the Fuzzy Score expresses the degree of consensus of the expert panel for a particular item, and the larger its value, the more the expert panel agrees with the item's representation of the IHTM usability elements.

2.3 Participants

A total of 37 interviewees were involved in this phase of the IHTM evaluation, all 37 were teaching staff in colleges with interdisciplinary teaching experience. Based on the gender and teaching experience of the respondents, their information is categorized here to reflect both gender and professional title. According to the data of the questionnaire's personal information, 10 of the respondents have the title of associate professor as defined as expert teachers, and the other 27 are teaching assistant and lecturers as defined as young teachers, gender and professional title of respondents are shown in Fig. 3.

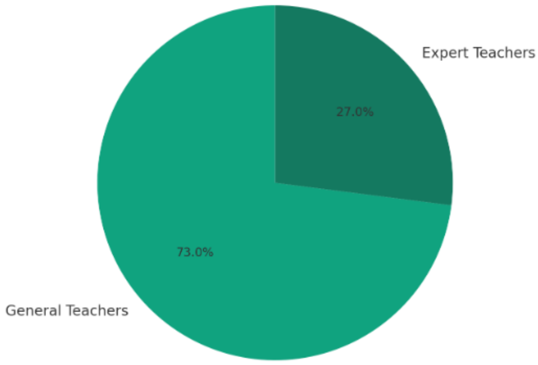

Fig. 3. Distribution of respondents by gender and seniority

In this study, a usability questionnaire with 5-point Likert scale was designed to evaluate the usability of the interdisciplinary HOT teaching module. The questionnaire was divided into two parts: demographic and scale questions, and all items were constructed to answer the research questions. After determining the reliability and validity of the questionnaire, it was distributed for data collection.

3. Findings and Discussion

In the overall results of the data analysis, the mean and standard deviation of all items are presented in the Table 2, which were obtained from the ratings given by 37 participants. The findings indicated that all scored more than 4.3, which indicated that the teaching module got the high assessment results in terms of usability and pedagogical objectives.

Table 2. Descriptive statistics

Items	Mean	Std. Deviation	N
IHTM helps to improve performance in interdisciplinary teaching and learning	4.49	.607	37
IHTM improves the cognitive breadth and intellectual literacy of students	4.68	.475	37
IHTM is suitable for instructional classrooms that enhance students' higher-order thinking	4.30	.571	37
The teaching module is a great tool for interdisciplinary teaching	4.16	.602	37
IHTM uses plain language that students can easily understand	4.62	.492	37
IHTM is suitable for teaching and learning to improve students' ability to analyze problems	4.70	.463	37
IHTM is applicable to instruction that enhances students' ability to assess problems	4.49	.607	37
IHTM is suitable for teaching students to improve their creative thinking skills	4.73	.450	37

As shown in Table 4, 55.4% of the respondents strongly agreed with the usability of this module, and 41.2% agreed with the usability, which shows that most of the respondents believe that the teaching module can achieve the desired teaching objectives and is implementable. 3.4% expressed neutrality, which means that they are not sure whether this module application can be implemented in the classroom or they are not sure if it can achieve the designed instructional objectives.

In addition, since a panel of 10 expert teachers was included in all the respondents, the degree of consensus of the expert panel was also one of the important indicators for evaluating the usability of teaching module. Therefore, here the fuzzy Delphi Method (FDM) was employed to calculate the degree of experts' consensus. Based on the eight questionnaire items for the usability evaluation, determining the experts' consensus about them requires first calculating the threshold value. According to Lin & Chuang (2012) given that the threshold had exceeded 75% which indicated that the experts had reached the required consensus, data indicated the respondents' evaluations about the usability were considered to be in consensus and the α- Cut > 0.5 for all items, which demonstrated the acceptance of this group of respondents for all of these items (Saido et al., 2018; Abdelgawad & Fayek, 2010). The results about the fuzzy number and the degree of consensus are shown in Table 5.

Table 4. Analysis on percentage and mean Score for the Items of usability

No.	Item	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean
1	IHTM helps to improve performance in interdisciplinary teaching and learning	0	0	5.4	40.5	54.1	4.49
2	IHTM improves the cognitive breadth and intellectual literacy of students	0	0	0	32.4	67.6	4.68
3	IHTM is suitable for instructional classrooms that enhance students' higher-order thinking	0	0	5.4	59.5	35.1	4.30
4	The teaching module is a great tool for interdisciplinary teaching	0	0	10.8	62.2	27.0	4.16
5	IHTM uses plain language that students can easily understand	0	0	0	37.8	62.2	4.62
6	IHTM is suitable for teaching and learning to improve students' ability to analyze problems	0	0	0	29.7	70.3	4.70
7	IHTM is applicable to instruction that enhances students' ability to assess problems	0	0	5.4	40.5	54.1	4.49
8	IHTM is suitable for teaching students to improve their creative thinking skills	0	0	0	27.0	73.0	4.73
Total (Average)		0	0	3.4	41.2	55.4	4.52

Table 5. Result for consensus

No.	Condition of triangular Fuzzy numbers		Condition of Fuzzy evaluation process				Expert consensus decision	Accepted element
	Threshold Value (d)	Percentage of Expert Consensus	m1	m2	m3	Fuzzy Score (A)		
1	0.181	90%	0.600	0.850	0.975	0.808	Reach consensus	0.808
2	0.144	100%	0.625	0.875	1.000	0.833	Reach consensus	0.833
3	0.118	90%	0.525	0.775	0.975	0.758	Reach consensus	0.758
4	0.159	80%	0.500	0.750	0.950	0.733	Reach consensus	0.733
5	0.139	100%	0.650	0.900	1.000	0.850	Reach consensus	0.850
6	0.092	100%	0.700	0.950	1.000	0.883	Reach consensus	0.883
7	0.169	90%	0.650	0.900	0.975	0.842	Reach consensus	0.842
8	0.121	100%	0.675	0.925	1.000	0.867	Reach consensus	0.867

4. Conclusion

This study evaluated the usability of an interdisciplinary teaching module that had been developed and its effectiveness in reinforcing higher-order thinking skills through a fuzzy Delphi method and descriptive statistics, and concluded that the module had good usability by comparing the means through a cut-off point method. In addition, a panel of experts was included among the participants, and a consensus was reached among the panel members that the module had good suitability in terms of interdisciplinary knowledge and enhancement of students' higher-order thinking skills, and that it would be suitable for instructors to use in their classrooms to implement in order to help undergraduates to develop more holistically.

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Conflict of Interest

The authors declare no conflicts of interest.

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