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Development of interdisciplinary Higher-order Thinking Teaching Module: Insights from Delphi Consensus

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Abstract

The aim of this study was to design and develop an interdisciplinary Higher Order Thinking Skills (HOTS) teaching module for first year university students. In order to derive appropriate elements of the teaching module in terms of interdisciplinary knowledge and HOTS, 18 experts were recruited to participate in the design development and module review. A total of 3 rounds of the Delphi method were implemented to derive the module elements, and we used interquartile range (IQR) and Z-score to determine the degree of consensus of the panellists, which resulted in 39 consensus module elements out of 41 items, which were consolidated into 7 constructs, and these were applied to the development of the teaching module.

Keywords: *Interdisciplinary; high order thinking (HOT); teaching module; delphi technique.*

Introduction

The contemporary world mirrors the integration of various disciplines, underscoring the role of universities in fostering interdisciplinary education. It is therefore incumbent upon universities to respond quickly to these challenges by trying in some ways to break away from the traditional teaching model of the sub-disciplinary system in order to facilitate the learning of knowledge outside the disciplines by university students. Interdisciplinary learning tackles complex issues that transcend the confines of a single discipline, highlighting the necessity of a holistic educational approach. University students need a more diversified disciplinary structure to face the challenges posed to them by a rapidly developing society. Numerous studies have demonstrated that students engaged in formal interdisciplinary courses exhibit a greater capacity for integrating multidisciplinary insights than those in traditional disciplinary courses, equipping them to tackle the emergent, uncertain, and paradoxical issues of society and the environment. (Yang xin, Ding rong, & Duan, Y. S., 2024).

Interdisciplinary education is considered to be an effective mode to cultivate T-type people (A wide range of knowledge and depth of expertise) with complex knowledge structure and higher-order thinking skills(HOTS)(Xu, D. Q., 2021). Similarly, HOTS are deemed essential skills for the new generation of university students. Consequently, we have designed and developed this module to merge the concepts of interdisciplinarity and HOTS, aiming to enhance the theoretical and practical aspects of this field in China.

Problems Statement

In recent years, the Ministry of Education has persistently highlighted the significance of holistic development in university students, alongside the incorporation of higher-order thinking (HOT) skills such as innovation, synthesis, and critical thinking, into educational goals. Despite policies highlighting the critical role of interdisciplinarity and HOTS, the response from Higher Education Institutions (HEIs) has been slow and insufficient (Lindvig, K., Lyall, C., & Meagher, L. R., 2019; Daniel, K. L. et al., 2022; Biseth, H. et al.,2022). In China, only a few universities have explored the development of interdisciplinary teaching modules, making the establishment of such programs a rare event.

Leng W. J., (2018) revealed that a majority of university students, particularly first-years, from various regions across the country, have high expectations for interdisciplinary teaching and strongly agree on the importance of interdisciplinary learning. Another persistent issue in Chinese classrooms is the excessive focus on teacher-centered instruction, where the teacher is viewed as the ultimate authority (Streich, P., Selke, R., & Saito, M., 2020; Du, Y. 2020; Fatima, A., et al., 2019). Clearly, this approach in the classroom

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does not foster the development of higher-order thinking skills, such as creative and integrated analytical thinking.

Additionally, Yang Xin et al. (2024) analyzed 287 reports on teachers' perspectives towards interdisciplinary teaching, finding that a substantial majority (70.3%) viewed the development of interdisciplinary thematic learning positively and deemed it essential for enhancing student competencies. Yet, 51.2% admitted to never attempting it due to various factors such as resource scarcity, inadequate knowledge, and unfamiliarity with its implementation. Furthermore, research by Self, J. A., Evans, M., Jun, T., & Southee, D. (2019) and Li, J. et al. (2022) identified issues in the methodological approach to curriculum and teaching module design, contributing to ineffective delivery of interdisciplinary courses.

Purpose of the Study

Considering the aforementioned issues, this study aims to develop an instructional design tailored for an interdisciplinary model. This involves creating a series of interdisciplinary HOTS instructional modules, encompassing elements like instructional objectives, content, and recommended strategies, to reconcile the discrepancies between prevailing theories and practical applications. This study is guided by the following two research questions:

Q1: What is the expert consensus on the design and development of interdisciplinary HOTS modules?

Q2: Based on expert consensus, how can an appropriate Interdisciplinary Higher-Order Thinking Module (IHTM) be designed and developed?

Literature Review

Literature review reveals numerous benefits of interdisciplinary courses, with positive outcomes derived from feedback by students, faculty, and external sources. The majority of literature on interdisciplinary courses assesses their positive impacts from two angles: one focusing on students' specific thinking skills and comprehensive attributes, like creativity and critical thinking (Lee, J. H., 2017; Harris, A. M., 2019; White, C. D., 2014). The other evaluates the positive effects of interdisciplinary learning on students' understanding of specific subjects or topics (White, C. D., 2014; Chen Yan & Xu, L. M., 2018; Ewane, 2023; Fang et al., 2023).

In the development of the teaching modules, we have made reference to theories and methodologies related to interdisciplinarity, higher order thinking and curriculum development. These encompass constructivist theory, Bloom's taxonomy of cognitive domains, and principles of curriculum design.

The concept of 'higher-order thinking' is often linked to Bloom's Taxonomy of Cognitive Domain in 1956 (Poluakan, C et al.,2019). The cognitive domain involves the development of knowledge and intellectual skills (Bloom, 1956). This includes the recall or recognition of specific facts, procedural patterns, and concepts that contribute to the development of intellectual abilities and skills. There are six major categories of cognitive processes, The revised version changes the original names to verbs, including Remember, Understand, Apply, Analyze, Evaluate and Create (Krathwohl, 2002) 。 Hsu, M. C. (2015) argued that teachers are more conducive to helping students develop higher-level cognitive thinking skills by using verbs to set instructional goals.

Given the teaching module's incorporation of diverse knowledge, and acknowledging the influx of new information, students' learning remains inherently linked to their existing cognitive structures. Accordingly, the theories of multiple intelligences and constructivism are integrated.

The theory of multiple intelligences significantly broadens the understanding of human intelligence, offering a multifaceted reinterpretation of what constitutes intelligence. It advocates for and facilitates the development of varied skills among students, both in academic settings and beyond (Weng R. M., 2021). The essence of constructivist learning theory is its student-centered approach, emphasizing learners' active exploration and discovery, as well as their engagement in constructing meaning from knowledge (Krahenbuhl, K. S., 2016).

Drawing on the aforementioned theories, we have integrated teaching and curriculum development theories with expert consensus surveys to develop appropriate teaching modules.

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Research Methodology

The purpose of this study is to design and develop interdisciplinary HOT teaching module base on experts consensus. The modules designed encompass all elements essential for classroom application, such as an introduction to the module, instructional objectives, teaching strategies, activities, and interdisciplinary knowledge.

The components of the interdisciplinary teaching module mentioned earlier are evaluated by experts in relevant fields, aiming to generate uniform advice for the development of course modules. This study progresses through ongoing interactions with these experts until coherent and viable recommendations are formulated, employing the Delphi technique for data analysis.

This study was conducted in Shandong Province, renowned as the cradle of Confucian culture and one of China's provinces most dedicated to education. This region's historical and cultural emphasis on education provides a rich context for examining interdisciplinary higher-order thinking skills within the Chinese educational system. Given the uniformity of the higher education system across China, the findings from this study offer insights applicable on a national scale.

The Delphi Technique

The Delphi techniques is commonly referred to as a consensus method (Jones &Hunter, 1995). In order to get consistent advice from experts in the field on the issues, it was necessary to go through multiple rounds of expert questioning during the survey.It is commonly used in situations where qualitative data cannot support decision making(Narayanan, H. P., 2019). Today, the Delphi method is often used to make decisions, develop policies and solve problems. In the field of education, the Delphi technique is widely used (Ismail,M., Aliah,N.,& Hassan,H., 2023). There are three characteristics that differentiate the Delphi techniques from other group inter action methods (Narayanan, H. P., 2019).

1. The experts are anonymous to each other, including their interactions and responses.

2.The technique utilises multiple rounds of questioning.

3. In between each round, feedback is given to the group

The main function of the Delphi technique is to reduce the bias in the conclusion. It involves multiple experts assessing the same issue through their individual theories and experiences, aiming to decrease systematic errors. The divergent perspectives of these experts on the issue are then either validated or revised in subsequent rounds of inquiry, facilitating the achievement of a stable resolution.

Participants

The participants of this stage are a panel of experts. For the design of module content, the correct selection of the composition of experts is very important for the effectiveness of this stage.According to Wang **&** Ho(2010), the experts should be selected based on the following criteria:

1. Knowledge and experience with subject:

2. Capacity and willingness to participate

3. Ability to contribute their opinions to the needs of the study and keen to revise their initial judgement to reach agreement among experts.

4. In addition, Scheele (2002) suggests three types of panelists to create a successful mix of individuals: stakeholders who are directly affected by the outcome,experts with specialties, and people with relevant experience in the field.

The majority of Delphi studies utilize a sample size ranging from 10 to 20 participants (Hsu, C. C., & Sandford, B. A., 2007). Stitt-Gohdes and Crews (2004) note that the optimal number of panel members may vary, but suggest that 10 to 15 participants are sufficient for a Delphi study with a focused group of participants. Consequently, this study selected a Delphi panel comprising 13 experts in related fields.

The 13 participants included university administrators and teachers, all with experience in teaching across disciplines and with expert experience in different areas of expertise, meanwhile fully understanding their

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students. These characteristics meet the requirements of course design and development at this stage and ensure the effectiveness and credibility of the interview. Refer to the table below for details of interviewees.

Table 1.

Participants	Field of teaching	Experience (in years)	Fields
1	General education	17	Management & Teaching
2	Course specialist	23	Management & Teaching
3	Course specialist	19	Management & Teaching
4	Science(physics)	14	Teaching
5	Science(biology)	12	Teaching
6	Science(engineering science)	16	Teaching
7	Humanities(philosophy)	17	Teaching
8	Humanities(history)	16	Teaching
9	Social science(psychology)	18	Teaching
10	Humanities (Chinese culture)	21	Teaching
11	Social science(economics)	15	Teaching
12	Humanities (Art)	14	Teaching
13	Science(Math)	19	Teaching

Regarding the number of Delphi rounds, from the literature reviewed above, it can be seen that most of the studies obtained group consensus on the use of 2-4 rounds of the Delphi questionnaire, with the 3-round Delphi method being used most frequently. Too many rounds can easily lead to overexhaustion of participants and even dropout (Thangaratinam & Redman, 2005), therefore, this study used 3 rounds of Delphi survey.

Data Collection

Round 1

The first round Delphi is a semi-structured interview with experts, based on Taylor's course theory and the orientation of the interdisciplinary HOT teaching module, included teaching objectives, modules content, Teaching strategies, etc., which served as the starting point of the survey. Semi-structured interview is flexible and allows interviewees to raise new questions in the process. This kind of interview gives interviewees time and space to elaborate more of their own opinions on specific topics. Nevertheless, the emphasis of the interview is determined by the researcher, The researcher needs to integrate more meaningful information, and if necessary, additional interviews with individual experts may be conducted at this stage to refine and correct questionable and divergent interview data. The steps of semi-structured interview are as follows:

1. Select experts to participate in the interview according to the research objectives and characteristics of research methods.

2. Clarify the purpose of the study, the need for expert assistance, an overview of the Delphi method and the arrangement of the three rounds of Delphi in this study, and to encourage group members to complete the interviews and questionnaires throughout the Delphi phase (Hasson et al.,2000).

3. Interviews were conducted with the panelists and the conversations were committed to be used for this study only, and with the consent of the members, the conversations were recorded for later compilation into text for the first round of data processing.

4. Development of a questionnaire on the development of teaching modules based on the content of the first round of semi-structured interviews for the second and third rounds of the Delphi phase.

本阶段的问题见表 4.1

NO.	Questions
Q1	We are developing a teaching module for enhancing HOTS and interdisciplinary knowledge, what are your views on this module development?
Q2	What do you think should be the pedagogical objectives of the module?

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Q3	What should be the characteristics of the module introduction?
Q4	What teaching strategies do you think are applicable to this module?
Q5	Suggested activities for the module based on your own teaching experience and the references provided?
Q6	What are your other suggestions for modules?

Round 2 & 3

The qualitative data from the first round of interviews were analysed thematically to derive elements of the Panel's recommendations for the teaching module. The questionnaire used for the second round of Delphi will be developed on the basis of the elements derived from the first round. In the second stage panelists were asked to rate their level of agreement with each item, so the options under each item were designed as a 4-point Likert scale, 1=strongly disagree, 2=disagree, 3=agree, 4=strongly agree, and experts were encouraged to make suggestions and comments on the evaluated items. After completing the statistics, the median and interquartile range of the entries were calculated and the median and interquartile range were marked on the questionnaire to form the third round of the questionnaire, where the experts could know the statistical results of the second round,in this way, experts in the third round of Delphi can refer to the previous consensus situation in order to give recommendations.

The third round of questionnaires was similar to the second round. In order to facilitate the final consensus, the order of the third-round questionnaire entries was arranged from highest to lowest consensus (based on the mean) in the second round. The median and interquartile range of the second round were marked after the entries, and the third-round questionnaire encouraged experts to leave comments after selecting items that differed significantly from the second-round median for the researcher's consideration.

Data Analysis

The data from the first round of interviews will be categorized according to the content for thematic analysis, and a questionnaire will be created for the second round of Delphi method according to the categories of the topics and the characteristics of the teaching modules developed. The second and third rounds were 4 levels of Likert scale data, and after the second round of data collection, the mean, median and interquartile range values were calculated and completed by SPSS software, and then the data were used for the third round of questionnaires.

Since the Likert scale is four levels, there may be many entries for the same median condition, therefore, according to the suggestion of (Ying Qin, 2018; Muhammad Faizal A. Ghani, 2014), the third round of the questionnaire can be rearranged according to the mean of the second-round items scores from the largest to the smallest, which can highlight the content with higher expert consensus, and these items are more important for module development with a higher probability of use.

The third round of the questionnaire also analyzed the mean, median and interquartile range (RQR) values of the data. The median indicates the value of higher agreement, i.e., the majority of experts chose the option with this level of agreement, and the interquartile range indicates the degree of expert consensus on the entries, here referenced Radzi, N. M., et al. (2015) by RQR to respond to the expert's consensus degree (table 3.7).

Table 3.7. Measurement of the level of consensus.

Consensus level	High	Medium	Minimal
RQR value	0-1	1.01 - 1.99	>2.0

In addition, in order to examine the differences between the data given by the experts of the 2 rounds, this study used the Z score for analysis. The Z-score can truly reflect the relative standard distance from the mean of a score, a Z score below -1.99indicates no significant difference between experts' ratings in the two Delphi rounds.In other words, a value below -1.99 indicates that ratings were consistent between both rounds.Whereas, a z score above -2.00 implies a significant difference between experts' opinions in round 2 and 3.(Radzi, N. M., et al., 2015).

Based on the experts' questionnaire, the entries with high level of consensus (IO value ranging from 0 to 1) and highlevel of agreement (median value of' >3) were selected as the final recommendations for the design of the teaching module.

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After collecting the final recommendations, the researcher developed the teaching modules based on the consensus of the experts, these consensuses include the introduction of the teaching module, the teaching objectives, the characteristics of the module, and the recommended teaching strategies and models. During the module design development process, we maintained contact with the Delphi panel to facilitate solicitation of details about module development.

Validity of the Module

The evaluation of validity included face validity and content validity, and such evaluation was based on the questionnaire used in the studies by Oluwatayo, J. A. (2012), Content validity refers to the extent to which the items in the instrument match the aspects being examined, and the content of the domain that should be studied (Ghazali Sufean.2016; 0luwatayo, 2012).

The face and content validity items were combined in one instrument so that participants could distinguish between the domains of the items when assessing the items in the instrument.In this study, the content validity mainly includes the elements used in the module, the applicability to the prior knowledge construction of the first-year students, the matching time of each part of the module, the content of the module and the level of the students, the suitability of the case content for the students to analyze, etc. Items of questionnaire uses five-point Likert scale answers,namely; 1(Strongly Disagree), 2(Disagree), 3 (Neutral), 4 (Agree) and 5 (Strongly Agree). At the end of the questionnaire, the experts were encouraged to give written suggestions for improvement of the problems. The questionnaire was divided into three parts, the first part was the profile of the experts who participated in the questionnaire, including age, gender and field, the second and third parts were the questionnaires on the face validity and content validity of the teaching modules, respectively. The questionnaire for module validity is shown in Appendix A.

The validity of the module was assessed by five participants, including curriculum, language, and subject specialists, all of whom possess significant interdisciplinary teaching experience and were asked to provide written feedback. Given that the module's foundational content received expert consensus during the Delphi phase, subsequent modifications were minor and confined to the original framework of the teaching module. Validity for each module component was established through the calculation of the Content Validity Index (CVI), with an item deemed valid if its CVI is at or above the acceptable threshold of 0.8 (Davis, 1992; Lynn, 1986; Polit, Beck, & Owen, 2007). Figure 1 shows the method and process for this study.

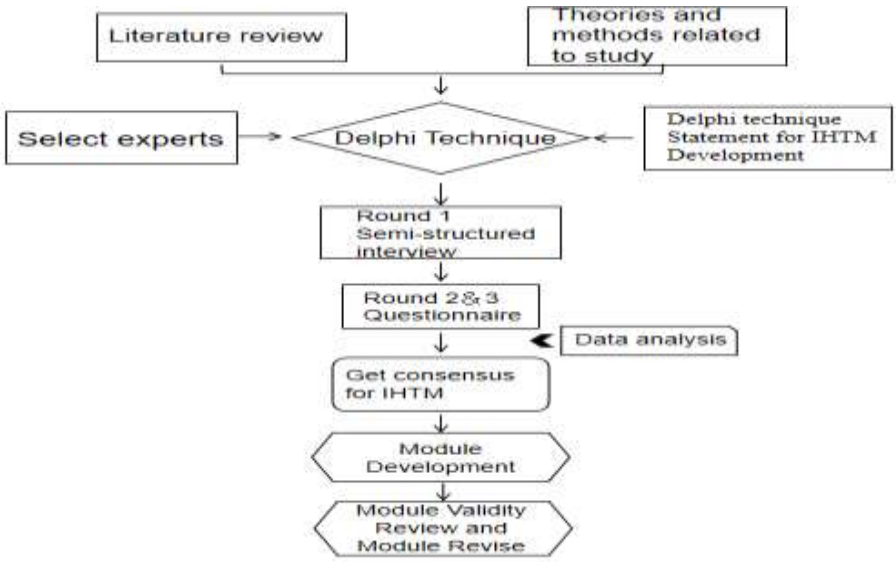

Figure 1. Summary of the process in this study.

Findings

The determination of module composition and characteristics requires multiple rounds of investigation. This study assumed 3 rounds of Delphi, the first round of Delphi aimed to collect experts' suggestions on

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the modules and collect qualitative data through interviews, the second round was to collect experts' consensus on the aggregated situation and combine it with the overall complementary opinions, and the third round resulted in the final consensus. After completing the module development, the module validity was reviewed.

Experts' consensus

Round 1

Qualitative data were obtained through interviews to obtain experts' recommendations for interdisciplinary HOT iteaching modules. The data were coded through carefully documented readings for thematic categorisation, these categories included module Sections, teaching objectives, Module Introduction, teaching strategies, Recommended module content, Module Features and resources. The qualitative data from this round of Delphi was collated into seven items, each section comprising of several sub-items, resulting in 34 items for the first round of Delphi as shown in Table 5.1. After this, a questionnaire was developed from these items for the second round of Delphi.

Table 5.1. Items recommended by experts in the first round delphi.

Theme	Items
T1: Sections of the teaching module	1.Teaching objectives 2.Course introduction 3.Module use of guideline 4.Disciplinary methodology 5.Interdisciplinary thinking 6.Classroom activities 7assignment
T2 Teaching objective	1 Connect to Bloom's 6 dimensions to develop higher cognition 2 Learn the underlying logic of different disciplines 3Broaden the cognitive domain of knowledge 4Learn the ability to learn 5Information Literacy: Teach students how to search, evaluate and use information effectively and avoid inaccurate or misleading resources. 6 Cross-cultural awareness: encourages students to understand and respect different cultures and perspectives, and to develop the ability to communicate across cultures.
T3 Module Introduction	1 Fascinating. 2 Feeling useful 3 Clear presentations
T4 teaching strategy	1 Student-centered 2 Students are advised to form groups and collaborate 3Teacher-Student Learning Classroom 4 Developing Problem-Solving Skills 5 Teaching scaffolding
T5 Recommended module content	1. thermodynamic entropy increase and human body dissipative structure 2. logic of engineering ---- decomposition structure 3. Functions and Speculation 4. Cognitive Traits and Marketing 5. Revelation of Statistics 6. The Collision of Traditional Chinese Culture and Science 7. Innovative practice
T6 Module Features:	1 Easy to understand presentation 2 Considering students' prior knowledge

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	3 Framework logic for different disciplines, providing different ways of thinking to develop students' thinking and cognitive breadth
T7 Teaching and Learning Resources	1 On-campus resources 2 Network 3 Audio-visual 4 Books

Round 2

A set of questionnaires was developed from the contents of Table 5.1 to solicit the Delphi panel's approval of the items. The purpose of this was threefold; firstly, participants were able to see a summary of other members' recommendations and were able to form a more holistic view, and secondly, based on the totality of the ITEMS, the experts were able to add written comments to refine the structure of the module. Third, the number of activities recommended by the experts for the teaching modules in the first round was more than the lesson design and needed to be cut.

Therefore, for this round of Delphi, the items collected in the first round were distributed to the Delphi panel, and the experts were asked to rate each item on a four-point Likert scale: 1=strongly disagree;2=disagree;3=agree;4=strongly agree. In addition, after each item the experts were allowed to leave written suggestions, which will be adopted and added to the third round of the Delphi questionnaire.

By using SPSS Version26, the data for this round presents the mean, median, first quartile Q1, third quartile Q3 and interquartile range Interquartile range (IQ) for each item. The mean serves as the level of expert agreement on the ITEMS, and the median and interquartile range serve as the basis for evaluating the level of consensus on the results of the next Delphi round.

The data from the second round of the Delphi technique was analysed as shown in Table 5.2.

Table 5.2. Data of 2nd round delphi

T1	**T1-1**	**T1-2**	**T1-3**	**T1-4**	**T1-5**	**T1-6**	**T1-7**		**T1 Additional Items**
Mean	4	4	3.77	4	3.77	4	3.23		**Unit Summary*
IQ	0	0	1	0	1	0	1		**Teaching and Learning Summary*
T2	T2-1	T2-2	T2-3	T2-4	T2-5				
Mean	3.69	4	2.84	3.77	4				
IQ	1	0	1	1	0				
T3	T3-1	T3-2	T3-3						
Mean	3.77	3.77	4						
IQ	1	0	0						
T4	T4-1	T4-2	T4-3	T4-4	T4-5				T4 Additional items
Mean	3.92	3.85	3.92	3.69	3.77				* Flexible classroom arrangements
IQ	0	0	0	1	1				*Flipped classroom
T5	T5-1	T5-2	T5-3	T5-4	T5-5	T5-6	T5-7		T5 Additional items
Mean	3.62	3.62	4	3.69	3.62	3.54	3.62		*Activities proposed for deletion
IQ	0	0	0	1	1	1	1		
T6	T6-1	T6-2	T6-3						T6 Additional items
Mean	4	3.92	3.92						*Relevant life and student development *proceed from shallow to deep
IQ	0	0	0						
T7	T7-1	T7-2	T7-3	T7-4					T7 Additional items
Mean	3.77	3.62	3.69	3.85					*Appropriate cell phone teaching software
IQ	0	1		0					

The data illustrate the scores for each of the items under the seven constructs (T1 to T7) comprising the module. With the exception of T2-3 (Logical Ability) = 2.84, the mean values are between 3 and 4, and the IQ values = 0 or 1, which indicates that the experts agree with the individualitems and have an acceptable degree of consensus to be used as a basis for the development of instructional modules. The mean = 3.32, median = 3, and IQ = 1 for the homework item indicates that the experts agree with this item and have a good degree of consensus, but the degree of agreement is low compared to the other ITEMS, so a moderate reduction in the design of the module can be considered.

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In addition, the experts suggested eight additional items, reflected in Table 5.1 above, which will be added to the third round of the Delphi questionnaire. In addition, several participants felt that the teaching activities should be deleted due to exceeding the lesson time of the curriculum. Therefore, the deletions will be decided in the third round based on the ranking of score averages.

Round 3

The third Delphi round seeks to achieve a definitive consensus among experts regarding module development. This round's questionnaire includes additional entries from the second round, featuring eight new questions across five constructs. These added questions will be placed at the end of each structure. In addition, the mean value of the score for each item in the second round was labelled after each item as a reference. The third round of Delphi's questionnaire is still left blank to receive open-ended suggestions from experts.

Similar to the previous two rounds of Delphi, the mean, median, and interquartile range IQ were used to respond to the level of expert agreement. Additionally, Wilcoxon signed ranks test was conducted in this round to check the difference between the scores given by the experts in Round 2 and Round 3 Delphi.As suggested by Radzi, N. M. et al. (2015), a Z score below-1.99 indicates no significant difference between the ratings in Round 2 and 3, whereas a Z score above -2.00 implies a significant difference between experts' ratings in both rounds.If the variability of theitems is within the acceptable range, the consensus of the experts on the module at this stage can be derived.

Table 5.3 shows the results of the third round of Delphi data, and these recommendations will be used as the basis for the development of the teaching modules.

Table 5.3. Data of 3nd round delphi.

T1	**T1-1**	**T1-2**	**T1-3**	**T1-4**	**T1-5**	**T1-6**	**T1-7**	***T1-8**	***T1-9**
Mean	4	4	3.85	4	3.85	4	3.31	3.77	3.62
IQ	0	0	0	0	1	0	1	1	1
Z-score	-1.000	-1.000	-0.137	-1.00	-0.137	-1.00	-0.564		
T2	T2-1	T2-2	T2-3	T2-4	T2-5				
Mean	3.69	4	2.84	3.77	4				
IQ	1	0	1	1	0				
Z-score	0	0	-0.577	-0.577	0				
T3	T3-1	T3-2	T3-3						
Mean	3.92	4	4						
IQ	0	0	0						
Z-score	-1.414	-0.083	0						
T4	T4-1	T4-2	T4-3	T4-4	T4-5	*T4-6	*T4-7		
Mean	4	3.92	4	3.85	3.85	3.38	3.77		
IQ	0	0	0	0	0	1	1		
Z-score	-1.000	-1.000	-1.000	-1.414	-1.000				
T5	T5-1	T5-2	T5-3	T5-4	T5-5	T5-6	T5-7	Slashed items	
Mean	3.77	3.69	4	3.85	3.08	3.23	3.61	**T5-6**	
IQ	1	0	0	0	0	0	1	**T5-7**	
Z-score	-1.414	1.000	0	-1.414	2.111*	-1.265	1.000		
T6	T6-1	T6-2	T6-3	*T6-4	*T6-5				
Mean	4	4	3.85	4	3.77				
IQ	0	0	1	0	1				
Z-score	0	-1.000	-1.000	-1.000					
T7	T7-1	T7-2	T7-3	T7-4	*T7-5				
Mean	3.85	3.77	3.77	3.92	3.69				
IQ	0	1.000	1.000	0	1.000				
Z-score	-1.000	-1.414	-1.000	-1.000					

In the third Delphi round, among the 41 items analyzed—excluding censored sections—the means ranged from 3.31 to 4, with medians of either 3 or 4. Notably, a median of 4 occurred in 35 items, representing

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85.36%. Both mean and median values suggest these items satisfy the teaching module development criteria, while an IQR of 0 or 1 signifies a consensus among the expert panel on these items.

The z-score was used to analyse the difference between the Delphi expert opinions in the second and third rounds, and the data pointed out that there was no significant difference between the expert opinions in the two rounds except for T5-5 ($-2.00 < Z < 0.00$), which was removed as a cell, suggesting that the experts reinforced their opinions. Additionally, the overall z-score was calculated to analyse the overall consistency between the second and third rounds ($Z = -1.518$, $p = 0.129 > 0.05$), all of which implies that the experts' evaluations were largely consistent across the two rounds.

Table 5.4 below indicates the mean values for the second and third rounds to compare the changes in the level of expert agreement. The mean, maximum minimum and median values point to a convergence in the level of expert agreement between the two rounds, with a slightly higher level of expert agreement on the overall evaluation in the third round than in the second round.

Table 5.4. Difference between round 2&3.

Delphi	N	Mean	Minimum	Maximum	Median
Round 2	429	3.77	2.00	4.00	4.00
Round 3	429	3.79	2.00	4.00	4.00

Module Validity Review

After completing the design and development of the modules, the instructional modules were presented to the experts for review to ensure the validity of the modules and to gather their recommendations. Based on the returned questionnaires, the facial and content validity scores of the module were derived and the following results were obtained by calculating the CVI as shown in Tables 5.5 and 5.6.

Table 5.5. CVI values for face validity: experts ' perception towards IHTM

NO	Items	CVI Value
1	Module is easy to use	1.0
2	Module can attract attention	1.0
3	The contents of the module are organized	1.0
4	The size of font is appropriate	1.0
5	The diagram is clear	0.86
6	Diagrams are easy to understand.	1.0
7	The level of language used is easy to understand	1.0
8	Average	0.98

For the facial validity of the module, the experts gave 1.0 for all the eight items except for the item on the representation of diagrams, which was 0.86, indicating that the designed module is basically suitable in terms of textual representation, font size, clarity of icons and comprehensibility. Regarding the diagrams, the experts pointed out a few pictures in the size and improvement measures in the written comments section, and these suggestions will be adopted and used in the improvement of the module.

Table 5.6. CVI values for content validity: Experts ' perception towards IHTM

NO	Items	CVI Value
1	Teachers can understand module content and apply it to their teaching.	1.0
2	The objectives of all activities are compatible with the module.	1.0
3	The title of each activity corresponds to the module.	1.0
4	The content of the module is reasonable in relation to its allocated time.	0.86

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5	The content of the module is relevant to expanding the breadth of knowledge.	1.0
6	The content of this module relates to higher order thinking skills.	1.0
7	The module correctly expresses the knowledge principle.	0.86
8	Modules provide accessible representations of disciplinary concepts.	1.0
9	The resources in the module are suitable.	0.86
10	The teaching software is suitable for IHTM.	1.0
11	Average	0.96

There were a total of 10 items for content validity, three of which had a CVI value of 0.86 and seven of which had a CVI value of 1.0, all of which were above the acceptable threshold of 0.8 (Davis, 1992: Lynn, 1986, Polit, Beck, & Owen, 2007)

Discussion

The consensus on the development of the module was identified through three rounds of Delphi, resulting in the elemental framework of the interdisciplinary HOTS teaching module, which is illustrated in Figure 2, which characterises the module in terms of its teaching objectives, module characteristics, recommended teaching strategies and teaching modes, as shown in Figure 2.

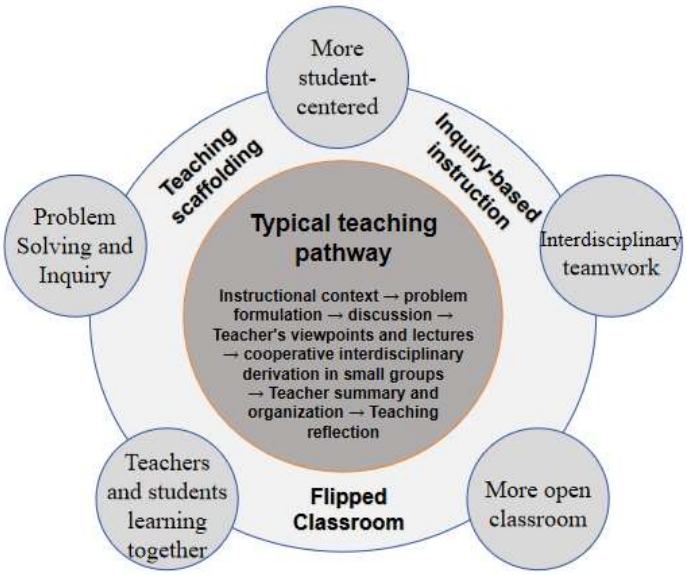

Figure 2. Framework of interdisciplinary HOTS module elements

Findings identified the characteristic elements that should be included in a module on teaching interdisciplinary higher-order thinking, and as the main aim of IHTM is to expand students' knowledge and enhance higher-order thinking skills, the expert emphasised the need for the module to be informed by Bloom's theory of cognitive domains. Next, the ability to learn to learn was also recognised as key to interdisciplinary learning, which is inextricably linked to the current educational regime of split-learning teaching, which is needed more than ever in order for students to learn other knowledge or skills. The need for teachers, who work with students in interdisciplinary learning, to develop independent learning skills has been widely recognised. Self-study is a meaningful approach and tool that can be employed to serve several purposes in the preparation of teacher educators. Through self-study, teacher educators can to a greater extend be able to capture, unpack and portray the complexity of teaching that can lead to a deeper understanding of both practice and students' learning processes (Hauge, K. (2021).

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Additionally, experts suggest that an interdisciplinary classroom has a greater need for engaging course introductions, especially appropriate for types of courses that students tend to under-appreciate at the outset, such as electives and online courses. Regardless of content and content delivery mechanisms, student engagement is critical to the success of instruction. Similarly, Khan, A.et al. (2017), in a study of strategies to enhance student engagement motivation in online teaching, noted the importance of instructional design and the need for teachers to be more intentional about this, such as more purposeful course navigation.

Regarding teaching methods, student-centred, more open classrooms where teachers and students learn together were agreed upon in the first round of Delphi At university, learning should not be based on memorizing/learning by heart a certain amount of information without applying it to real life situations.The teacher's role is to help students look for valuable solutions to open ended problems, being aware that there might be more than one solution to a problem, or that there might be several ways to tackle the problem (Condrat, V. 2018).

Some experts have suggested flipped classroom which is more applicable to the characteristics of this module.Akçayır, G., & Akçayır, M. (2018). A systematic review ofliterature on flipped classroom concluded that the benefits of this teaching strategy, including the possibility of better student performance, more conducive to discussion and analysis,student-initiated learning and problem-solving based classroom. Research has also pointed out that students may be more satisfied with the flipped method and it can be more economical than traditional instruction (O' Flaherty, J., & Phillips, C. (2015)) These are consistent with the findings of this study.

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Since mobile phone teaching software is used in the module, the validity assessment includes the suitability of the software, which is one of the important means of informative teaching to better adapt the module and bring better classroom interactions Lu, K., et al. (2021). The study proved such a viewpoint by pointing out the advantages of smart classroom in enhancing students' higher-order thinking skills through a survey of 217 first-year Chinese university students. this result may be explained by the fact that the smart classroom is a student-centered learning environment. Unlike the traditional teacher-centered classroom, a student-centered classroom is a place where the students are actively involved in the learning process, and two factors, motivation and peer support, are clearly conducive to promoting students' higher-order thinking skills in a smart classroom.

Ultimately, experts assessed the module's apparent and content validity, confirming it met the necessary standards but noted minor areas requiring adjustments and enhancements. Consequently, the module underwent further optimization in response to these insights.

Overall, the entire process of developing the interdisciplinary HOTS instructional modules was complete and stable, including soliciting expert input, reaching consensus, module development and validity REVIEW, and culminating in an instructional product that can be implemented and evaluated.

Limitations and Implications

Conducted in Shandong Province, this study's findings partially reflect the regional context. However, given Shandong's prominence as a key educational and economic province in China, the findings are broadly applicable to universities and educators across the country, owing to the uniformity of the Chinese education system. However, geographical constraints mean that some factors related to humanities, economic conditions, and social concepts have been excluded from consideration. The impact of these

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excluded factors on the teaching and learning of interdisciplinary and higher-order thinking skills requires additional investigation.

As a study of module development in interdisciplinary categories, there is a rich diversity of module content, so the activities included in this module are limited. However, the development of more such modules can be informed by our expert consensus-based elemental framework in the Delphi Technique, which interdisciplinary teachers can use as a basis for designing and implementing richer pedagogical content.

Given the rich diversity of module content in interdisciplinary categories, this module includes a limited range of activities. Nevertheless, the development of additional modules can benefit from our Delphi Technique's expert consensus-based framework. Interdisciplinary teachers can leverage this as a foundation for designing and implementing more comprehensive pedagogical modules.

Therefore, to enhance students' interdisciplinary and higher-order thinking skills, we propose a systematic framework for interdisciplinary teaching modules to develop a comprehensive teaching module. This framework outlines a general pedagogical approach tailored to the teaching module, ensuring the process is suitable for classrooms focused on interdisciplinary higher-order thinking skills. Initially, teachers introduce scenarios related to the content, engage students with questions, and interact with them. Following the introduction of expertise, interdisciplinary elicitation encourages the application of knowledge and broadening of students' thinking. Students form interdisciplinary groups, actively participating in teaching and learning activities, presenting their findings, and engaging in flipped classroom approaches. Moreover, modules with an interdisciplinary focus are designed to weave multidisciplinary knowledge into each activity, facilitating problem analysis and solution. The module designs are grounded in established pedagogical objectives, offering both theoretical and practical guidance for interdisciplinary teaching and fostering higher-order thinking skills in university students.

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Appendix A

Face and content validity questionnaire (FOR IHTM)

This table consists of three parts:

Part I: Demographic Data

Part II: Face Validity

Part III: Content Validity

Part I: Demographic Data

Your Name:

Your title/position:

Your field of endeavor:

Years of experience:

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Part II:Face Validity

Instructions：Please mark "√" in the table of your choice.

Likert Scale	**1**	**2**	**3**	**4**	**5**
	Strongly disagree	Disagree	Neutral	Agreed	Strongly Agree

	Statements	**1**	**2**	**3**	**4**	**5**
1	Module is easy to use					
2	Module can attract attention					
3	The contents of the module are organized					
4	The size of font is appropriate					
5	The diagram is clear					
6	Diagrams are easy to understand.					
7	The level of language used is easy to understand					

Suggestion for improvement：

Part III: Content validity

Instructions：Please mark "√" in the table of your choice.

Likert Scale	**1**	**2**	**3**	**4**	**5**
	Strongly disagree	Disagree	Neutral	Agreed	Strongly Agree

	Statement	**1**	**2**	**3**	**4**	**5**
1	Teachers can understand module content and apply it to their teaching.					
2	The objectives of all activities are compatible with the module.					
3	The title of each activity corresponds to the module.					
4	The content of the module is reasonable in relation to its allocated time.					
5	The content of the module is relevant to expanding the breadth of knowledge.					
6	The content of this module relates to higher order thinking skills.					
7	The module correctly expresses the knowledge principle.					
8	Modules provide accessible representations of disciplinary concepts.					
9	The resources in the module are suitable.					
10	The teaching software is suitable for IHTM.					