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Constructing a Framework to Promote Higher Order Thinking Skills in One-to-One Western Classical Instrumental Music Classroom among Students in Higher Education

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Abstract

Researchers have persistently to urge the importance of strengthening students' higher-order thinking skills (HOTS) as a pivotal in addressing contemporary educational challenges. However, fostering HOTS engagement among students in one-to-one Western Classical Instrumental Music (WCIM) instruction presents a formidable obstacle. This study aims to construct a framework to assist teachers in enhancing students' HOTS engagement in one-on-one WCIM instruction settings. Seven experts employed Adversarial Interpretive Structural Modeling (AISM) to hierarchically establish relationships among strategies. Subsequently, the Impact Matrix Cross-Reference Multiplication Applied to a Classification (MICMAC) analysis was utilized to categorize the identified strategies for enhanced comprehension. The framework comprises 16 teaching strategies, culminating in a topology diagram featuring five distinct domains. Each strategy is elaborated upon and categorized with the HOTS attribute, denoted by active verbs within the Revised Bloom's Taxonomy. This topological representation can be seamlessly integrated into pedagogical practices within one-to-one WCIM classrooms. Educators have the flexibility to select either the entire framework or specific domains for implementation. Additionally, the outcomes of the MICMAC analysis reveal the presence of five dependent elements, four linkage elements, and seven driving elements, albeit with no autonomous element identified. The outcomes of this study could aid educators in effectively fostering students' utilization of HOTS, thereby enhancing students' proficiency in WCIM, fostering their personal development, and promoting sustainable educational practices within the WCIM.

Keywords: Western Classical Instrumental Music, High Order Thinking Skills, One-to-one Classroom Practice, Framework, Strategy

Introduction

In contemporary educational landscapes, the cultivation of higher-order thinking skills (HOTS) has emerged as a crucial focal point, driven by the evolving demands of the 21st century (Fensham & Bellocchi, 2013; Ganapathy et al., 2017). These skills are essential for equipping students with the ability to solve complex problems (Brookhart, 2010; Gupta & Mishra, 2021), think critically (Sidiq et al., 2021; Singh & Marappan, 2020), and engage in metacognitive processes, thereby fostering their adaptability and innovation in an ever-changing world (Sidiq et al., 2021; Singh & Marappan, 2020). The significance of HOTS extends beyond academic success, as they are increasingly recognized as fundamental competencies for personal and professional development (Conklin et al., 2012). Despite the extensive research and emphasis on HOTS in various educational domains, the realm of Western classical instrumental music (WCIM) education, particularly in one-to-one instructional settings, remains underexplored (Ng et al., 2022). This gap is significant because WCIM education, with its rich traditions and emphasis on technical mastery, often prioritizes practical skills over cognitive development. Consequently, there is a pressing need to investigate how HOTS can be effectively integrated into WCIM instruction to enhance students' musical understanding, problem-solving abilities, and overall proficiency. This study addresses this need by constructing a framework designed to promote HOTS among students in higher education one-to-one WCIM classrooms. The framework aims to provide educators with practical strategies and a structured approach to foster HOTS, ultimately benefiting students by empowering them to become independent thinkers and problem solvers in their musical endeavors. By emphasizing the utility and effectiveness of HOTS in WCIM education, this study seeks to contribute to the broader discourse on educational reform and sustainable practices within music education.

Classroom practice is critical to achieve the goal of developing students' HOTS (Lu et al., 2021; Miri et al., 2007). The teacher's role in teaching and learning classroom activities aimed at developing students' HOTS include guidance, asking advanced questions based on the students’ knowledge and extending them (Bjorklund & Causey, 2017). Nevertheless, it suggests that classroom instruction aimed at nurturing students' HOTS often demands substantial expertise (Sada, 2019; Ballakrishnan & Mohamad, 2020), thereby presenting a challenge for teachers in implementing this objective. Furthermore, previous researches have pointed out that teachers seem to have inadequate strategies to effectively motivate students thinking skills in instrumental music teaching lesson (Costes-Onishi & Kwek, 2022; Holmgren, 2020; Woodford, 2018).

While the advancement of HOTS has been extensively investigated in scientific domains, the realm of music education, notably within the context of Western classical instrumental music (WCIM), remains relatively nascent. Western classical music is also called "Classical music" or "Western art music". The former is a common-sense term (Bull, 2019), and the latter is a term often used in academic research (Becker, 1986; Drummond, 2010). With developing a solid tradition, this music education has been formalised with the introduction of conservatoire teaching in the nineteenth century, dating back as far as the Middle Ages (Lawson & Stowell, 2012). With emphasizing of hands-on knowledge, practical skills, and expertise, certain practitioners perceive WCIM as a discipline characterized by physical mastery involving control and restraint (Johnson & Graziano, 2003; Bull, 2019). Practical knowledge is attained through processes such as modeling, demonstration, imitation, and application. Within this framework, daily technique lessons are considered the predominant method of instruction, as they serve to enhance students' technical prowess (Ng et al., 2022).

However, López-Íñiguez and Pozo (2014) have criticized traditional practices among higher education teachers in WCIM, noting that the transmission of personal beliefs to students can potentially erode their intrinsic motivation to use thinking skills. This critique has been supported by several other studies as well. For example, Carey and Grant's (2015) research in Australia higher education agrees with Bautista's (2010) research conclusion on European conservatories of music, pointing out that some students are not independent, nor do they expect themselves to be knowledge builders. Holmgren (2020) also agreed that WCIM higher education students are not good at interpreting music which is regarded as a critical ability. These claims corroborate earlier suspicions that researchers did not believe that students' could transfer their knowledge to solve problems in WCIM leaning (Sheldon et al., 2010; Gaunt, 2009; Kemp & Mills, 2002). This matter has inspired researchers to come up with new ideas to improve the teaching of WCIM and develop students' higher order thinking skills (HOTS) is a viable option (Ng et al., 2022).

The development of HOTS for WCIM learners fosters independent thinkers and problem solvers. Learners who lack such expectations are constrained by fragile and nontransferable information (Sheldon et al., 2010). Students, especially those in higher education studying music education, who lack HOTS may face challenges in developing their students' HOTS effectively during their careers (Kaya & Bilen, 2021). This situation does not contribute to a virtuous cycle for the overall enhancement of instrumental music instruction. Unfortunately, the extant literature on HOTS in WCIM (Ng et al., 2022; Siow, 2015) is still in its infancy. There is insufficient theoretical data available to guide teachers in effectively fostering students' HOTS in the classroom. Therefore, establishing a framework to assist teachers in effectively fostering students' HOTS in one-to-one WCIM classrooms is crucial. This framework not only supports student performance and personal development but also facilitates transformative progress in one-to-one WCIM instruction. Additionally, it has the potential to offer fresh perspectives on other forms of instrumental music teaching and learning.

Research Objective

This study aims to develop a framework to assist instructors in enhancing students' HOTS practices in one-on-one WCIM classrooms in higher education. By rationalizing the sequence of strategy elements' implementation, this framework could effectively support teachers in promoting students' HOTS in WCIM. To achieve this objective, the following specific goals need to be achieved: 1) identifying effective strategies; 2) identifying HOTS attributes that can be stimulated through these strategies; 3) determining the sequential implementation of strategies to construct a comprehensive framework; 4) elaborating and analyzing each strategy in detail. The process of accomplishing each goal is outlined in this report.

Methodology

Research Method

In terms of the construction of the framework, seven experts were recruited to participate in a one-day focus group discussion (FGD) to complete the target by Adversarial Interpretive Structure Modeling (AISM) method. The AISM method was used to establish the interrelationships between the strategies for promoting students practice on HOTS. AISM is derived from the traditional ISM method, which was proposed by Warfield in 1973, and is mainly used to analyse the constituent elements of complex systems together with their interdependencies and constraints. The fundamental principle of ISM involves breaking down the components of a complex system into several sub-elements. Through a series of topological operations, a single hierarchical graph is systematically derived with a focus on achieving specific outcomes. Huang (2003) introduced adversarial ideas on top of the result-oriented hierarchical sorting rules of the ISM. Then, the elements are sequentially ordered from bottom to top to create an AISM method. Compared to ISM, AISM generates a more explicit and hierarchical topology map. It achieves this by representing influencing factors as nodes and using directed line segments to indicate nodes with causal relationships. This enhanced clarity of representation not only facilitates accurate structuring of the system but also aids users in comprehending and utilizing the framework effectively within the classroom setting.

To date, ISM has been successfully used in studies of instructional model building (Rezaei et al., 2022; Jain et al., 2022). However, AISM has not been incorporated into the education research domain, although it has been widely used in model building studies for cause exploration or strengths and weaknesses analysis. Since the goal of this study is to accomplish the sequential ordering of instructional strategies that help stimulate students HOTS, the AISM methodology is applicable. Furthermore, it could also be a methodological breakthrough in this study.

As for the identification and connection of strategy elements, this study employed expert FGD, a regular activity in the ISM methodology (Ahmad & Qahmash, 2021). This expert FGD mainly utilised the Nominal Group Technique (NGT) as a procedural guide. NGT provides a systematic approach to gathering meaningful and trustworthy qualitative input from a group of experts in a focus group environment (Jamieson et al., 1998). Some researchers suggested that NGT increases the utility of focus groups by collecting data on a specific topic or question and prioritising problems and issues through group debates (Langford et al., 2002). It enables divergent perspectives on a shared topic to be voiced and compiled in order to uncover areas of agreement and set goals for change.

Participant

The seven expert participants in this study were chosen using a purposive sampling approach, which involves deliberately selecting sampling units from a specific segment of the population that has the most information related to the characteristic of interest (Guarte & Barrios, 2006). This approach ensured a heterogeneous group of experts with diverse perspectives and expertise relevant to the research topic. Based on the literature, it is recommended that the size of an ISM-FGD meeting be restricted to a maximum of eight participants (Janes, 1988), as the quality of discussion tends to decline when the number of experts exceeds eight. All seven experts willingly participated in the meeting and completed the informed consent forms. Comprehensive background information for each expert is presented in Table 1. Three experts specialize in the field of education, whereas the remaining four are affiliated with WCIM teaching. The three experts in education have conducted research on HOTS, while the four WCIM teachers specialize in violin, piano, tuba, and percussion, representing the principal categories of Western instruments. All seven experts selected for this study have amassed more than seven years (Berliner, 2004) of experience working in universities within their respective domains. Additionally, they hold either PhD degrees or positions as associate professors or professors, indicating a high level of expertise and knowledge in their fields.

Table 1
Summary of experts' personal information

No.	Area of Expertise	Gender	Academic qualification	Title	Age	Teaching years in higher education
E1	WCIM education (Piano)	Male	Master	Associate Professor	52	27
E2	WCIM education (Violin)	Male	Master	Associate Professor	45	22
E3	WCIM education (Woodwind)	Male	Master	Associate Professor	48	20
E4	WCIM education (Percussion)	Male	PhD	Lecturer	41	8
E5	Education	Female	PhD	Associate Professor	40	10
E6	Education	Male	PhD	Associate Professor	42	13
E7	Education	Male	Master	Professor	60	32

Procedural Stages of Framework Construction

To construct the framework, several sequential steps need to be followed. Although AISM was selected as the final framework for visually presenting the results, some intermediate steps involved regular processes of ISM, like step 5. The steps are specified below:

1. Confirmation of initial strategy element list;
2. Deliberation by experts to finalize the roster of strategy elements and identifying the HOTS attributes associated with each element;
3. Establishment of an original matrix;
4. Development of a reachable matrix via tier extraction and mapping the directed topological hierarchy;
5. Secondary modifications to the topological map and regionalization; and
6. Determine the elaboration of each strategies and HOTS attribute adjustment.

Instrument and Data Analysis

This study was generate various types of data, including process data generated during framework construction meetings and data used for interpreting the final framework. During the seven-expert meeting, three instruments were employed. Tool 1 comprised a seven-point Likert scale questionnaire designed for rating element sequences, which aided in selecting initial and terminal elements for implementation. The aggregate score of each item was utilized to determine the overall ranking, with a score of 7 indicating the earliest occurrence and 1 indicating the latest. Tool 2 was an element connection voting table, featuring a blank matrix akin to Figure 5, devoid of content. The seven experts evaluated the elements based on the sequence of their pairwise occurrences. Subsequently, the median of the votes was utilized to establish the original matrix. Tool 3 was an AISM generator (accessible via https://www.huaxuejia.cn/ism/cal_aism.php), designed to generate AISM topology maps from the original matrix. Additionally, the entire conference proceedings were recorded to facilitate the summarization of the elaboration of each strategy element in the framework and the HOTS attributes.

For the final framework analysis, the Cross-impact matrix multiplication applied to classification (MICMAC) was utilised to identify the strategies with the driving and dependence power. In this study, the traditional MICMAC analysis was employed for analyzing the strategy elements. Unlike AISM's system-type interpretation, MICMAC tends to focus more on the characteristics of each element. This approach aids users in gaining a clearer understanding of each strategy element within the context of the overall framework. The MICMAC analysis conducted in this study utilized SmartISM to generate the final graph (available at http://smartism.sgetm.com/ISM.aspx/). However, as this generator only accepts ISM element connection symbols, it became necessary to convert the final Topological Map into an SSIM matrix. The decision not to directly convert the original matrix into SSIM was influenced by the experts' secondary adjustments to the initial topology map derived from the original matrix. The symbols V, A, X, and O in Table 2 represent the relationships between pairs of elements in the framework according to specific rules.

Table 2
Symbolic conversion of topological map

Relationship between elements	Show in the Topological Map	Symbol
Element 'i' is happened before element 'j'	i→ j or i→ x→ j	V
Element 'i' is happened after element 'j'	j→ i or j→ x→ i	A
Element 'i' and 'j' are happened together	i ⇄j	X
Elements 'i' and 'j' are unrelated.	i j	O

Construction of the Framework

Step 1 Confirmation of Initial Strategy Element List

In most ISM and AISM studies, elements are screened through an extensive literature review. However, in this study, strategy elements were derived from 20 Strategies of Brookhart's (2010) “How to Assess higher order thinking Skills in Your Classroom”, which is an important guide for instructing students to practice HOTS in the classroom (Brookhart, 2010, p.144-147). This is a more structured guide than an extensive literature search. These 20 strategies are viewed as critical elements supporting the enhancement of students' engagement with HOTS. However, this list represents only an initial set of strategy elements. While Brookhart provided guidelines along with instructions and material suggestions for these strategies, they did not specify the specific HOTS that each strategy can inspire nor the rational sequence in which strategies are effectively stimulated. The next step will determine whether the strategy elements will be retained or added and HOTS attribute of each strategy element.

Step 2 The Final List of Strategy Element and the HOTS Attributes for Each Strategy

The initial 20 strategies were discussed by the experts where 16 were retained (Table 2). These strategy elements were retained because they met the WCIM instructional needs, help stimulate students' HOT, and they do not overlap with other strategies. Meanwhile, the HOTS attributes were retrieved from the expanded list of active verbs from RBT (Anderson & Krathwohl, 2001). The Revised Bloom’s Taxonomy (RBT) is an important theoretical foundation in HOTS, adapted from classical Bloom's (1956) original cognitive taxonomy. Anderson and Krathwohl categorised the cognitive learning domain goals from low to high. Remember (C1), Understand (C2), and Apply (C3) as LOTS; analyse (C4), Evaluate (C5), and Create (C6) as HOTS. Each level has specific verbs and thought descriptions that support each goal level. In this study, this framework will be used as a categorisation method of HOTS specific thinking skills. The active verbs under each level were used for a more detailed categorisation of HOTS, as listed in Table 3.

Table 3

List of active verbs for Analysing, Evaluating, and Creating in RBT

C4 Analyzing	C5 Evaluating	C6 Creating
4.1 Differentiating 4.2 Organizing 4.3 Attributing	5.1 Checking 5.2 Critiquing	6.1 Generating 6.2 Planning 6.3 Producing

Since the some strategy elements’ HOTS attribute was changed by the expert in Step 6, the milestones are not reported here.

Step 3 Building the Original Matrix

Based on the list of strategy elements, the experts conducted a scoring exercise to ascertain the priority of strategies for implementation in the classroom (refer to Table 4). This assessment was conducted using a seven-point Likert scale. The aim was to identify the initial and terminal strategies that would best suit the implementation process of this study, thus preventing over-iteration and maintaining the structure of the framework. The subsequent step involved expert scoring to establish the sequential order of the strategy elements, followed by the construction of an original matrix. During the implementation in classroom teaching, if the horizontal strategy (i) should occur before or at the same time as the vertical strategy (j), it is noted as 1, otherwise it is noted as 0. The experts agreed that the final result will be based on more than half of the votes cast, i.e., the final result should receive at least four votes in favour. Based on this assignment rule, an original matrix was constructed (refer to Table 5).

Table 4
Priority voting results for 16 strategy elements (7 = first to complete; 1 = latest to complete)

No.	Strategies	E1	E2	E3	E4	E5	E6	E7	Total
S1	Focus on a question or identify the main idea	7	3	3	1	2	5	5	36
S2	Analyze arguments	5	4	4	5	6	4	3	31
S3	Compare and contrast	6	7	6	5	4	5	6	39
S4	Evaluate materials and methods for their intended purposes	4	4	5	4	6	4	4	31
S5	Put unlike things together in a new way	5	5	4	3	5	6	5	33
S6	Assess their own work	5	5	5	5	6	5	4	35
S7	Make or evaluate a deductive conclusion	1	2	1	1	2	2	1	10
S8	Make or evaluate an inductive conclusion	2	1	2	2	2	1	2	12
S9	Evaluate the credibility of a source	4	2	2	1	2	2	6	19
S10	Identify implicit assumptions	5	6	4	3	4	3	7	32
S11	Identify or define a problem	6	7	7	7	7	7	6	47
S12	Identify irrelevancies to solving a problem	3	2	3	4	7	3	6	28
S13	Describe and evaluate multiple solution strategies	3	5	4	6	5	4	4	31
S14	Model a problem	5	6	5	4	6	3	2	31
S15	Identify obstacles to solving a problem	3	4	6	3	2	6	2	26
S16	Think creatively	5	6	7	6	6	6	7	43

Table 5.
Original matrix (Vote)

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
S1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0
S2	1	0	0	0	0	0	1	1	0	1	0	0	0	1	1	0
S3	1	1	0	1	0	1	0	1	0	1	0	1	1	0	1	0
S4	0	1	0	0	1	0	0	1	0	1	0	1	0	1	1	0
S5	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0
S6	1	0	0	1	1	0	1	1	0	0	0	1	0	0	1	0
S7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S8	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
S9	0	1	1	0	0	1	1	0	0	1	0	0	1	0	1	0
S10	1	1	0	0	0	0	1	1	0	0	0	0	0	1	1	0
S11	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1
S12	1	0	0	0	1	0	0	1	0	1	0	0	0	1	1	0
S13	1	0	0	1	1	0	0	1	0	0	0	1	0	1	1	0
S14	1	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0
S15	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
S16	0	1	0	1	1	0	0	0	0	1	0	1	1	1	0	0

*Step 4 Building the Reachable Matrix Via Tier Extraction and Mapping the Directed Topological Hierarch***y**

The data calculation for this portion of the content was conducted during a break in the session using AISM calculation software. The reachability matrix is a matrix format that delineates the distance path between the nodes of a directed connection diagram after a specific length of passage. The reachable matrix is calculated by B = A + 1, where B is the multiplication matrix, i.e., the diagonals all have 1 added to obtain their value; 1 is the unit matrix; and multiplying B together gives the reachable matrix R:

Table 6
Reachable matrix

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
S1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0
S2	1	1	0	0	0	0	1	1	0	1	0	0	0	1	1	0
S3	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	0
S4	1	1	0	1	1	1	1	1	0	1	0	1	0	1	1	0
S5	1	1	0	1	1	1	1	1	0	1	0	1	0	1	1	0
S6	1	1	0	1	1	1	1	1	0	1	0	1	0	1	1	0
S7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
S8	1	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0
S9	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0
S10	1	1	0	0	0	0	1	1	0	1	0	0	0	1	1	0
S11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S12	1	1	0	1	1	1	1	1	0	1	0	1	0	1	1	0
S13	1	1	0	1	1	1	1	1	0	1	0	1	1	1	1	0
S14	1	1	0	0	0	0	1	1	0	1	0	0	0	1	1	0
S15	1	0	0	0	0	0	1	1	0	0	0	0	0	0	1	0
S16	1	1	0	1	1	1	1	1	0	1	0	1	1	1	1	1

In a reachable matrix, there is a reachable set R, a prior set Q, and a common set T, where T = R ∩ Q. In the case of a relational matrix A, for example, for its element Ti: 1) All the elements of an element that correspond to a row value of 1 are called reachable sets R(Si); 2) All the elements of an element with a corresponding column value of 1 are called the prior set Q(Si). 3) The common set of the reachable set R(Si) ∩ Q(Si) and the prior set is called T (Si). The specific results are shown in Table 7.

Table 7
Reachable set R, prior set Q, and common set T

i	R(Si)	Q(Si)	T(Si)
1	1, 7, 8, 15	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16	1, 8, 15
2	1, 2, 7, 8, 10, 14, 15	2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 16	2, 10, 14
3	1, 2, 3, 4, 5, 6, 7, 8, 10, 12, 13, 14, 15	3, 9, 11	3
4	1, 2, 4, 5, 6, 7, 8, 10, 12, 14, 15	3, 4, 5, 6, 9, 11, 12, 13, 16	4, 5, 6, 12
5	1, 2, 4, 5, 6, 7, 8, 10, 12, 14, 15	3, 4, 5, 6, 9, 11, 12, 13, 16	4, 5, 6, 12
6	1, 2, 4, 5, 6, 7, 8, 10, 12, 14, 15	3, 4, 5, 6, 9, 11, 12, 13, 16	4, 5, 6, 12

7	7	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	7
8	1, 7, 8, 15	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16	1, 8, 15
9	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15	9, 11	9
10	1, 2, 7, 8, 10, 14, 15	2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 16	2, 10, 14
11	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16	11	11
12	1, 2, 4, 5, 6, 7, 8, 10, 12, 14, 15	3, 4, 5, 6, 9, 11, 12, 13, 16	4, 5, 6, 12
13	1, 2, 4, 5, 6, 7, 8, 10, 12, 13, 14, 15	3, 9, 11, 13, 16	13
14	1, 2, 7, 8, 10, 14, 15	2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 16	2, 10, 14
15	1, 7, 8, 15	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16	1, 8, 15
16	1, 2, 4, 5, 6, 7, 8, 10, 12, 13, 14, 15, 16	11, 16	16

Hence, the up-type and down-type topological hierarchy diagram were extracted. The former is also known as result-first hierarchy extraction as it places the extracted elements on the top layer. Whereas, the latter extracted the causes first and placed them at the bottom of the hierarchy (refer to Table 8). The directed topological hierarchy diagram can be created based on the relationships between the items and results of confrontation hierarchy extraction (refer to Figure 1).

Table 8
Adversarial hierarchy extraction results

Levels	Results First – Type UP	Reasoning First – Type DOWN
Level 0	S7	S7
Level 1	S1, S8, S15	S1, S8, S15
Level 2	S2, S10, S14	S2, S10, S14
Level 3	S4, S5, S6, S12	S4, S5, S6, S12
Level 4	S13	S13
Level 5	S3, S16	S3
Level 6	S9	S9, S16
Level 7	S11	S11

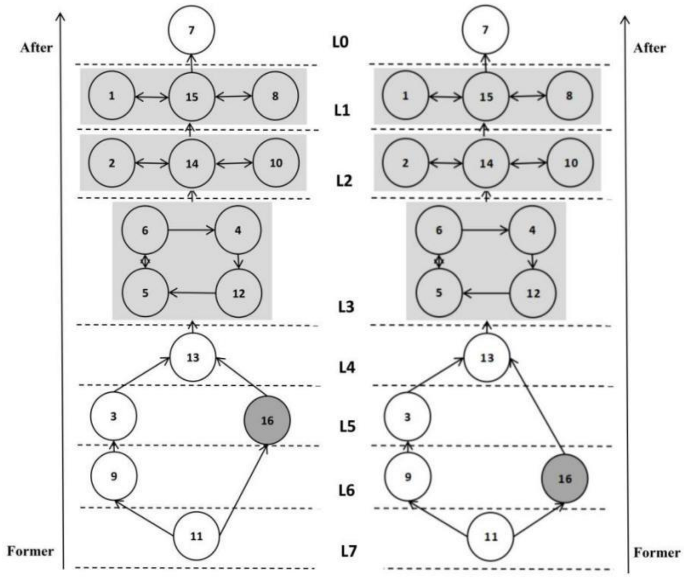

Figure 1 Up-type and down-type topological hierarchy diagram

Step 5 Secondary Adjustments in Topological Map and Regionalisation

In general, there is no secondary adjustment step in AISM studies, but is a routine step in the ISM which helps the expert to further examine and confirm the final results (Kumar & Goel, 2022). At the same time, the final topological hierarchy was regionalised by experts to better explain its structure. This section still employed the NGT model for the discussion. After re-examining the original framework, the experts unanimously took the following decisions. They: 1) divided the framework into five domains, namely: Identifying Problems and Proposing Potential Solutions, (Trying to) Solve Problems, Reflections, Summaries, and Transfers; 2) moved Strategy 9 before Strategy 7; 3) adjusted the relationship between strategies in Identifying Problems and Proposing Potential Solutions; and 4) renamed Strategy 7, 8, and 13. The experts are of the opinion that this entire topological map can be integrated into teaching and learning in a one-to-one WCIM classroom. Additionally, educators have the option to choose one or more domains for application based on their specific needs and preferences. The final adjustment result is illustrated in Figure 2.

Step 6 Determine the Elaboration of Each Strategy and HOTS Attribute Adjustment

Once the final topological map was validated, the experts engaged in further discussions regarding the specific use for each strategy. This step was included because the elaboration of the strategy elements is crucial for understanding their context. Additionally, during this step, some of the HOTS attributes were re-evaluated to ensure alignment with the internal logic of the framework. The experts' opinions on the elaboration of the strategy elements were then summarized.

Frameworks Visualisation and Strategy Elaboration

Visualisation and Overview of the Framework

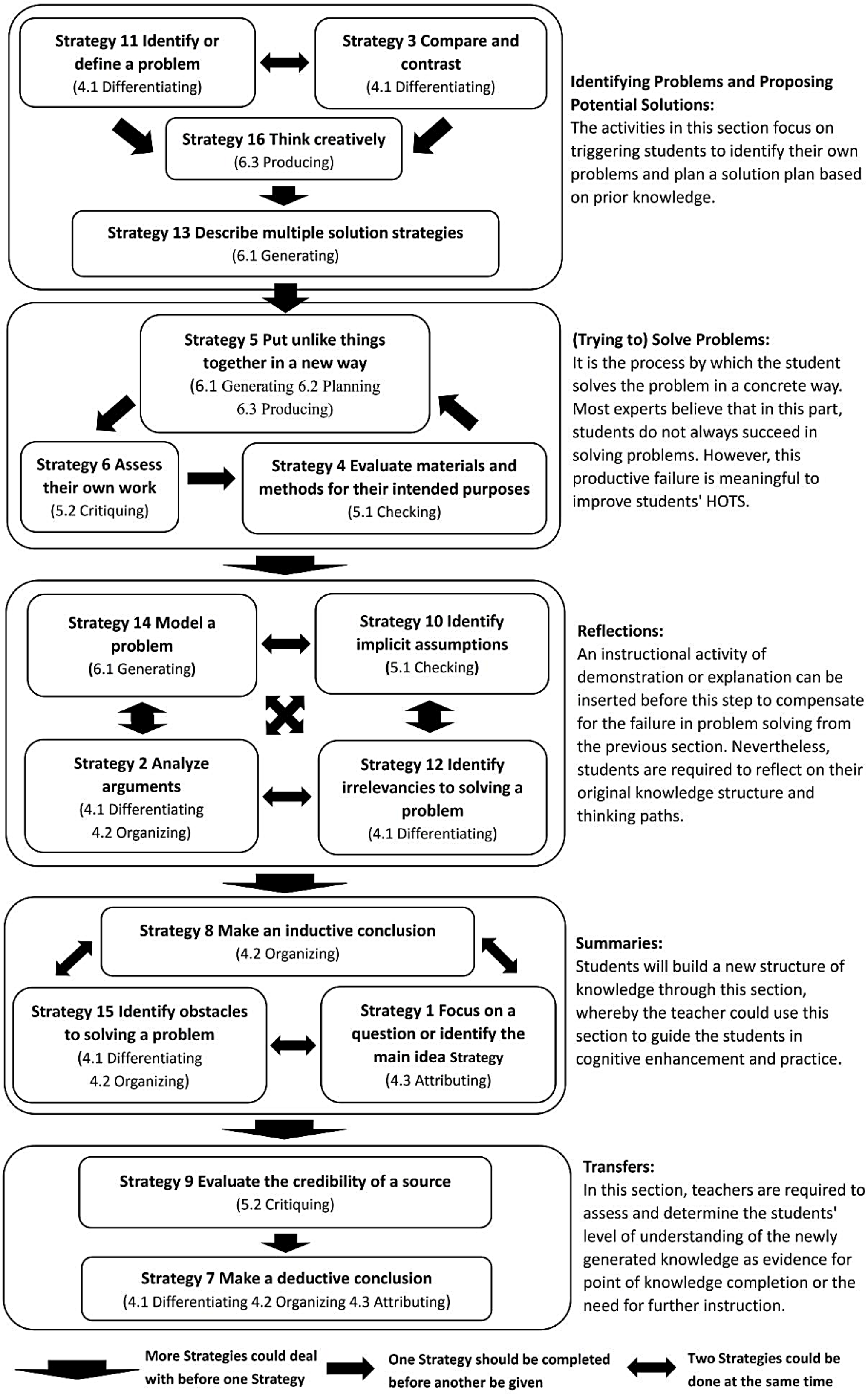

Figure 2 A framework for stimulating student HOTS in the WCIM one-on-one classroom

Elaboration of Each Strategy Element

Strategy 1 Focus on a Question or Identify the Main Idea

This strategy should generally be placed following a comprehensive discussion for a convergent summary. Hence, the questions need to be formulated in such a way that students do not have to base their answers on existing memories or the points teacher has just stated. Students should develop personal inductive understanding from the discussion to justify their final understanding. In conclusion, teachers must pay more attention to the logic and explanatory process of the students' ideas.

Strategy 2 Analyse Arguments

This strategy involves the analysis of an argument, where the student's perception of the causality of the premises from which an argument arises is assessed to understand the structure of the student's knowledge in a particular area. Therefore, both the teacher and student need to agree on the point of view of the argument before proceeding with this step for specific analysis. If not, communication may become ineffective. To ensure effective communication, the teacher must encourage the students to make their own analyses as much as possible, and less comprehensive but original analyses carried out by students remain examples of analyses. Students can only analyse and evaluate effectively through personal analyses, otherwise it's just repeating what others have said (C1 Remembering) or reaching a level of understanding (C2).

Strategy 3 Compare and Contrast

On this task, the teacher needs to avoid students giving very abstract brief responses (one played well, one not so well) or concluding answer (like the third bar is played differently on both occasions). If time is of the essence, teacher can prompt students to make comparisons on key elements. If there is enough time and students are expected to form their own structural framework, the teacher can ask them to look for more than one element to compare and to be able to distinguish whether they are the same or different in terms of the elements. Here is an example of one of the better responses, "These two times are identical in sound and rhythm, but different in intensity, and although they both do crescendo and have similar amplitudes, one starts the crescendo at an earlier point and the other later."

Strategy 4 Evaluate Materials and Methods for Their Intended

The objective in this strategy should be known (consented by teacher and students). This strategy is to test whether the student is clear enough about the criteria set for the objective, whether he/she understands the results and whether there is a gap between the two. It differs from Strategy 6 in that students need to focus on whether the problem is solved, rather than whether they follow the proposed solution plan.

Strategy 5 Put Unlike Things Together in a New Way

This strategy focuses on stimulating and assessing students' creativity based on their thought process. This creativity emphasises the synthesis of new elements into an internally logical aspect, instead of its originality and uniqueness. A creative thinking process is difficult to assess, hence, is usually assessed based on the student's performance (application results). The teacher has to ensure that the student obtains the result without imitation (the teacher's demonstration). Since the result of the student's personal assessment may not be perfect, the teacher should encourage him/her to attempt to answer based on their personal understandings.

Strategy 6 Assess Their Own Work

In this step, the student needs to assess whether he or she is working on the problem as planned, rather than the outcome of problem solving. At the same time, the teacher needs to ascertain that the cognitive load of the student does not overload while performing this task as it can lead to failure of assessment. Therefore, the use of video footage of the students is an effective mitigation method.

Strategy 7 Make a Deductive Conclusion

This strategy tests whether the student can apply a practical principle or abstract method to a real example, i.e., generate a result by reasoning. If the student fails to perform the task, the teacher needs to focus on whether it is a problem of understanding the principle or a difficulty in generating a deduction as they are unable to imagine. When the student finds it difficult to generate the answer, the teacher can provide the student with a few options to simplify the task. However, the ultimate goal is for the student to generate the result (not imitate). Once the students are able to answer correctly, a similar task needs to be added where this time the teacher should not provide any options, but let the students to generate the answer by themselves.

Strategy 8 Make an Inductive Conclusion

This strategy is similar to Strategy 7 because they are based on logical reasoning. However, Strategy 8 involves convergent inductive thinking, while Strategy 7, divergent deductive thinking. Therefore, both strategies employ similar points.

Strategy 9 Evaluate the Credibility of a Source

The focus of this strategy is to understand the transformation of the student's newly developed ideas and knowledge model. Therefore, real recordings or performances can be used for the evaluation purposes. Exaggerated demonstrations must be avoided if the performance demonstration is provided by the teacher. Additionally, the teacher could keep one correct element (e.g. rhythmic or connective correctness) together with an erroneous element, to avoid obvious or easily recognisable errors. Similar care needs to be taken while giving ideas or summarising sources.

Strategy 10 Identify Implicit Assumptions

This strategy requires students to reason through their prior knowledge to identify the hidden elements that are taken for granted and is a complementary task to Strategy 2. This strategy aims to enrich the knowledge model or make the logic more complete by identifying the hidden arguments. Based on recommendation, this step can be skipped if the students are already under cognitive load; if students' cognitive load is not very heavy, but are just struggling with the identification of the critical point, the teacher can then provide them with multiple options for them to choose from.

Strategy 11 Identify or Define a Problem

Problems can be identified for two reasons: the student's dissatisfaction with their performance or the teacher's dissatisfaction with the student's performance. The former is more effective than the latter in motivating a series of subsequent tasks. Alternatively, students can be given a second chance to play and revise their failed performance. Although it is common for the teacher to find multiple areas that need to be addressed or adjusted after the students' playing, the teacher has to ask the student whether any questions have arisen from the session or goals that have not been met. Once the student acknowledges complete satisfaction with the current performance, the teacher can then anchor the pending issues according to the frequently occurring types of errors by assessing the student's ability to resolve the issue (based on the current knowledge of the student) or by high-confidence errors (student is pretty sure of but are in fact wrong).

Strategy 12 Identify Irrelevancies to Solving a Problem

This strategy is usually a reflective conclusion that arises after having had the experience of a failed attempt at a solution. It can be used as a process step to test the current thinking model. This conclusion is usually not a translatable final conclusion; its significance lies in the convergence of thinking during the reflective process.

Strategy 13 Describe Multiple Solution Strategies

In this strategy, the teacher gauges the students' knowledge through their narratives. This strategy is usually premised on a brainstorming session that encourages students to generate more solutions. However, if students face difficulties in generating solutions (or brainstorming), the teacher can provide options for students to choose from and in return ask them to provide justifications. It is highly recommended for the teacher to retain this step to avoid students to imitate the teacher to solve the problems (examples given in the Strategy 3).

Strategy 14 Model a Problem

This strategy tests the student's overall comprehension. The teacher may ask the student to express his/ her understanding of the current problematic environment with a combination of-illustrations. It is a prerequisite for the creation of Strategy 8, which can be developed into a transformable conclusion.

Strategy 15 Identify Obstacles to Solving a Problem

This strategy is based on a summary after analysis. Students are required to summarise the barriers they face hindering their competence level by abstracting and analysing the outcomes of their previous session. This strategy will assist in deepening the students' understanding of their self-competence which would be helping students to anchor the direction in which they need to be working on after the lesson.

Strategy 16 Think Creatively

Although this strategy seems similar to that of Strategy 5, they are different. Strategy 16 is orientated towards brainstorming original production, whereas Strategy 5 is a combined production of multiple objectives. One of the similarities lie in teachers having to make sure that the students' ideas are original and are not based on recall. It is the teachers' responsibility to motivate the students to be original through positive feedbacks.

MICMAC Analysis of the Framework

The final framework diagram was converted to Structured Self-Interaction Matrix (SSIM) before the MICMAC analysis can be performed (Table 9). The final results of the analysis are illustrated in Figure 3, which are classified into four clusters:

1. Autonomous: Strategy elements with a weak driving power and weak dependence power; No strategies in this framework fall under this cluster. In other words, each of the 16 strategies within the framework has strong structural properties.
2. Dependent: Strategy elements with a weak driving power but a strong dependence power; Strategies 1, 7, 8, 9, and 15 are included in this cluster. Therefore, these strategies should ideally be implemented with a relatively strong pre-textual underpinning, otherwise they may be hindered in their concrete implementation. At the same time, they are highly convergent and can serve as an effective closure for teaching and learning activities on knowledge points.
3. Linkage: Strategy elements with strong driving and dependence power; Strategies 2, 10, 12, and 14 are included in this cluster, signifying their role as a carrier.
4. Driving: Strategy elements with a strong driving power but weak dependence power; Strategies 3, 4, 5, 6, 11, 13, and 16 are included in this cluster. Therefore, these strategies need to be prioritised for implementation as they act as a guide. Since they play an open-ended role, it is desirable that some convergent strategies (i.e.; Strategies 1, 7, 8, 9, and 15) need to be added after their implementation.

Table 9
SSIM of final topological map

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
S1		A	A	A	A	A	V	X	V	A	A	A	A	A	X	A
S2			A	A	A	A	V	V	V	X	A	X	A	X	V	A
S3				V	V	V	V	V	V	V	X	V	V	V	V	V
S4					V	A	V	V	V	V	A	V	V	V	V	A
S5						V	V	V	V	V	A	V	A	V	V	A
S6							V	V	V	V	A	V	A	V	V	A
S7								A	A	A	A	A	A	A	A	A
S8									V	A	A	A	A	A	X	A
S9										A	A	A	A	A	A	A
S10											A	X	A	X	V	A
S11												V	V	V	V	V
S12													A	X	V	A
S13														V	V	A
S14															V	A
S15																A

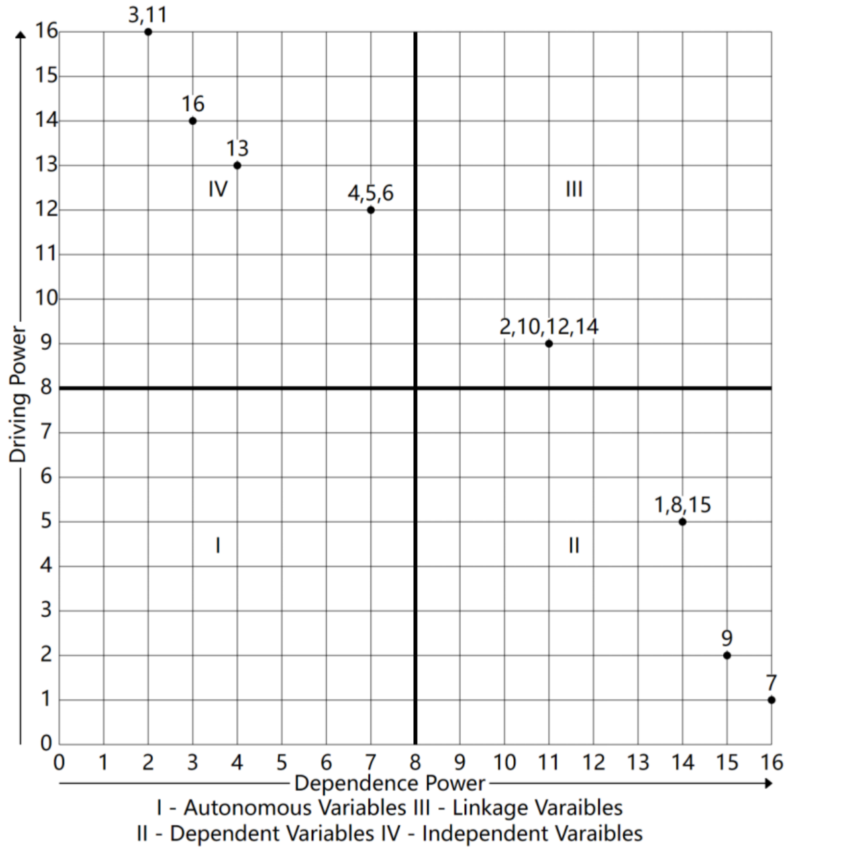

Figure 3 Cluster of each strategy element

Discussion

In general, the whole framework is basically in line with the process of WCIM teaching, but at the same time, it has been adjusted with the traditional teaching activities. Firstly, the framework enhances students' self-awareness by prioritizing their ability to independently identify and address problems. This addresses the limitations identified in one-to-one WCIM instruction, as emphasized by Schmidt (2012) and Holmgren (2020). In traditional WCIM contexts, it is the teacher rather than the students who usually identifies and offers solutions to problems. Meanwhile, academic research has long reached a consensus that the generation of HOTS necessitates the integration of students' subjective knowledge to comprehend and process novel information (Lewis & Smith, 1993; Newmann, 1990). However, disparities in knowledge structures between students and teachers may result in deviations from expected standard responses by students employing HOTS. Despite potential imperfections in students' knowledge structures, educators are encouraged to embrace students' utilization of their existing knowledge frameworks rather than dismissing them outright. Furthermore, the application of HOTS in problem-solving endeavors, particularly with complex issues, often encounters challenges. Despite the possibility that students may not immediately resolve the problem and may experience what Kapur (2008) terms as productive failure, engaging in the problem-solving process facilitates the integration of their pre-existing knowledge. Therefore, educators are advised to provide encouragement and recognition to students who engage in HOTS, regardless of the outcome or completeness of their problem-solving attempts.

Secondly, it emphasises the process of self-reflection and summarisation to motivate students to express their ideas through language and drawing, where fosters a dialogic teaching environment. Heron & Palfreyman (2023) emphasised that the recognition of quality educational discourse can increase teachers' and students' metacognitive awareness of the role of dialogic seminar discourse in developing disciplinary understanding. Additionally, it allows the teacher to get a clear picture of the student's knowledge structure. Teachers can enhance their understanding of students' knowledge structures and identify potential areas of concern for teaching practices. .

Finally, the whole framework is in line with the level of cognitive load tolerated by the students. For example, strategies begin with more around Analysis (C4), than come to more high-level HOTS (C5 or C6) because these domains allow students use their existing knowledge to solve problems. However, the later domains (Summaries and Transfer) in the framework stimulate students' lower HOTS skills (C4). Students usually need to incorporate newly learned knowledge into HOTS at this point, so lower levels of HOTS are relatively unlikely to cause cognitive overload. Furthermore, leveraging insights gained from students' comprehension levels, the HOTS attributes, and the MICMAC analyses of strategies within the framework, educators possess the autonomy to choose either the comprehensive framework or specific domains for deployment. This flexibility empowers educators to optimize instructional effectiveness and foster heightened engagement of students' HOTS.

Conclusion

In the realm of one-on-one WCIM instruction, cultivating students' HOTS presents a pressing challenge. The insufficiency of HOTS development among students in this context underscores its pivotal importance. A fundamental contributing factor to this challenge is the dearth of effective pedagogical strategies among instructors. Consequently, this study endeavors to formulate a structured framework aimed at fostering HOTS practices within the one-to-one WCIM instructional setting within higher education. This framework is anticipated to assist instructors in enhancing students' HOTS by rationalizing the implementation of effective strategies. The study utilized 16 effective strategies, with input from 7 experts using AISM to establish the sequential relationships among these strategies for implementation. Additionally, experts provided comprehensive explanations for each strategy element to aid instructors in effectively integrating these strategies into their classrooms, with the goal of inspiring students' HOTS. Finally, the MICMAC analysis shows the driving and dependence power of each strategy, which helps instructors combine and rationalise these elements more freely in the actual classroom. In the broader context, this study is expected to help educators reassess their classroom strategies and enhance their confidence in nurturing students' HOTS in WCIM lessons. By fostering student HOTS, it has the potential to establish a sustainable environment for teaching and learning in WCIM. This not only boosts students' confidence and ability to tackle challenges in their professional and personal lives but also contributes significantly to the overall development of the WCIM industry.

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