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Knowledge Graphs Empowering Innovation and Practice in Flipped Classrooms: A Case Study of the "History and Appreciation of Western Music" Course in Higher Normal Education

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Abstract: Against the backdrop of educational digital transformation, traditional teaching models for higher normal education courses in Western music history face challenges. This paper proposes integrating knowledge graphs with flipped classrooms as an innovative approach. Pre-class construction of knowledge graphs and problem graphs visualises key concepts and establishes logical connections. During class, a 'case-linked graph' serves as the core, guiding students to conduct in-depth analysis of musical works, thereby promoting knowledge internalisation and dynamic generation. Post-class, students systematically review and dynamically refine the knowledge and problem graphs developed during pre- and in-class sessions via an intelligent platform. Coupled with a dynamic comprehensive evaluation system, this enables multidimensional competency assessment. Practice demonstrates that this model significantly enhances students' systematic cognition, learning initiative, and comprehensive abilities, offering valuable insights for the digital transformation of musicology courses.

Keywords: Knowledge Graph, Flipped Classroom, Western Music History, Digital Transformation in Education, Problem-Oriented Approach.

1. Introduction

Against the backdrop of deepening digital transformation in education, exploring teaching models for higher music education that align with the characteristics of the intelligent era has become a critical focus in current music education reform. Confronted with the limitations of traditional teaching models in content organisation, interactive methods, and learning assessment, the flipped classroom offers a pathway to student-centred pedagogical transformation through its structural advantage of 'online pre-learning + offline inquiry'. Concurrently, knowledge graphs, as a structured knowledge visualisation technology, are emerging as vital tools underpinning digital instructional design. By constructing conceptual nodes and their interconnections, they not only enhance the perceptibility of knowledge systems but also enable optimisation of cognitive pathways and management of learning processes.

As a core module in higher music education programmes, Western Music History and Appreciation encompasses diverse dimensions including musical styles, composers, representative works, and cultural contexts. Its intricate knowledge framework and complex historical trajectory have long presented pedagogical challenges characterised by 'lecture-dominated delivery, fragmented comprehension, and fragmented cognition.' Consequently, scholars have explored solutions through knowledge architecture, pedagogical models, and resource integration. For instance, Zhao Weiping et al. (2018) investigated visual teaching strategies for ancient musical notation knowledge graphs. These studies provide theoretical and practical foundations for the digital transformation of music curricula. However, existing research predominantly focuses on the preliminary construction of teaching formats or the functional application of resource platforms. There remains a lack of systematic pathways tailored to the distinctive characteristics of music education, particularly concerning how to construct systematic cognitive pathways centred on knowledge graphs and deeply embed them within flipped classroom teaching processes.

Consequently, this study, grounded in the Higher Education Teacher Training programme's Western Music History and Appreciation course, explores how knowledge graphs can empower flipped classrooms. It aims to achieve the organic integration of 'knowledge transmission-aesthetic perception-cultural understanding,' thereby constructing a new form of intelligent teaching that is systematic, interactive, and adaptive. This approach addresses the current practical challenges faced by higher education music curricula in course design, the development of students' cognitive abilities, and competency assessment.

2. Current State and Innovative Pathways for Western Music History Courses in Higher Normal Institutions

Within higher normal institutions, Western Music History serves as a core compulsory module for music majors and constitutes a foundational theoretical course enabling students to gain in-depth understanding of Western music. It aims to systematically trace the developmental trajectory of Western music, encompassing stylistic characteristics, schools of thought, composers, and works across distinct historical periods. However, with the advancement of educational digitalisation, traditional teaching models and monolithic instructional methods have increasingly revealed limitations. They struggle to cultivate students' multifaceted abilities-such as musical appreciation, teaching practice, and comprehensive analysis-required to meet the diverse talent development demands of primary and secondary school music education. Consequently, Western Music History

courses in higher normal institutions face the critical task of transitioning from traditional to modern teaching approaches. Moreover, the presentation of knowledge within traditional teaching models often lacks clarity and intuitiveness, hindering students' ability to deeply analyse the intrinsic logic behind stylistic evolution across different periods and to untangle the intricate threads of musical development. Currently, assessment in Western music history courses at higher education institutions predominantly relies on closed-book examinations, with content emphasising rote memorisation of foundational knowledge such as composers' biographies, stylistic characteristics, and work titles. This approach struggles to evaluate students' phased learning outcomes or comprehensive competencies like independent study abilities. It also hinders teachers' capacity to adjust teaching content and strategies based on real-time learning progress, and impedes the formation of comprehensive, objective evaluations of student learning achievements.

Addressing these challenges, the flipped classroom model demonstrates its pedagogical superiority. As an innovative, student-centred approach, its core strength lies in transcending traditional teaching limitations. Students utilise online platforms to independently acquire foundational knowledge and historical-cultural contexts prior to class. Digital resource repositories resolve issues such as the extensive scope of Western music works and complex information retrieval, enabling resource sharing and personalised learning. In the classroom, the teacher assumes a guiding and inspirational role, focusing on interactive discussions, problem-solving, and practical application. Through collaborative analysis of musical works' stylistic features, cultural metaphors, and aesthetic values, students deepen their understanding and sensory experience of Western musical culture. This elevates their comprehension from the technical level of 'recognising melodies' to the cultural level of 'spiritual understanding'. Furthermore, practical classroom sessions reinforce the application of teaching skills, ultimately establishing an educational model that achieves deep integration between theory and practice, knowledge and professional competence.[1-6]

Additionally, the introduction of knowledge graph technology offers an innovative pathway for flipped classrooms. Knowledge graphs represent a form of knowledge visualisation, essentially constituting a structured representation of knowledge. Traditional teaching methods struggle to help students grasp abstract concepts. Knowledge graphs, however, visualise knowledge by constructing networks of connections between knowledge points. This enables students to intuitively comprehend the intrinsic logic of knowledge points, master abstract concepts and complex subject matter, and enhance their cognitive and learning abilities. Furthermore, knowledge graphs serve as visual representations of teaching content, enabling students to clarify learning objectives and content frameworks before course commencement, thereby enhancing learning focus. Given the intricate knowledge network and expansive knowledge system of Western music history, constructing a knowledge graph can clearly and intuitively display the connections between various knowledge points. This facilitates students' more efficient learning of fragmented knowledge points and systematic organisation of the historical development of Western music. Furthermore, as an underlying architecture supporting digital textbooks, the knowledge graph integrates multimodal resources such as text, audio, video, and animation, thereby aiding in the creation of a multidimensional cognitive pathway. Each knowledge node links to rich media resources. For instance, the 'Baroque concerto' node connects to detailed knowledge, performance videos of the Brandenburg Concertos, structural diagrams of the concerto grosso, and animations illustrating Baroque orchestra instrumentation. This forms a cognitive pathway of 'conceptual understanding – auditory experience – visual representation'. Moreover, constructing a question graph helps students consolidate knowledge points during the process of formulating and answering questions. This enables students to pursue clear objectives during self-directed learning, precisely grasp key concepts, and thereby enrich the knowledge graph. Furthermore, dynamic analysis of learning behaviour data within the knowledge graph allows teachers to clearly identify mastery levels of specific knowledge points and related concepts, enabling them to adjust teaching priorities. Students can also pinpoint their knowledge gaps based on their learning progress and undertake targeted study, thereby enhancing learning efficiency.

3. Architectural Design of Knowledge Graphs Empowering Flipped Classrooms

Within the architectural design of flipped classrooms for Western Music History, students undertake self-directed learning via online platforms prior to lessons. This enables them to acquire foundational knowledge of Western music history and understand essential historical and cultural contexts, thereby establishing a robust knowledge base for in-depth exploration during face-to-face sessions. During the in-person learning phase, students build upon their pre-acquired foundational knowledge to conduct in-depth analysis and exploration of musical works within Western music history, delving into the historical significance and humanistic ideas embedded within these compositions. During class, a 'case-linked diagram' is constructed, radiating outward from specific works to connect related knowledge points. Through in-person sessions' deep analysis and problem-based inquiry, the pre-class knowledge and problem diagrams are refined, enriching their content and enhancing their systematic completeness. Post-class, students utilise an intelligent online platform to systematically review and dynamically refine the knowledge and problem diagrams developed before and during class. This study examines how constructing knowledge map frameworks facilitates pedagogical innovation in flipped classrooms, using the Western Music History course at Zhejiang Normal University's School of Arts as a case study.[7-10]

3.1. Pre-class: Constructing Knowledge and Question Maps

The Western Music History knowledge maps in this study employ four presentation formats: tree diagrams, ring diagrams, network diagrams, and personalised maps. The tree diagram employs a hierarchical structure of 'central theme → branch points' to present knowledge clearly. Unlike the linear structure of tree diagrams, the ring diagram utilises a circular framework. Its primary advantages lie in its unique structural characteristics and suitability for disciplinary knowledge, where all nodes are evenly distributed around the centre, forming a balanced interconnected network. (See Figure 1) The circular structure inherently guides learners to focus on

the relationship between the whole and its parts, making it suitable for the 'systematic integration of fragmented knowledge' in Western Music History, avoiding the visual clutter caused by excessive branching seen in mind maps. Network diagrams and personalised maps employ radial annotations to form matrix-style associations. Personalised maps adopt a dual-layer architecture system of 'knowledge units – knowledge points'.

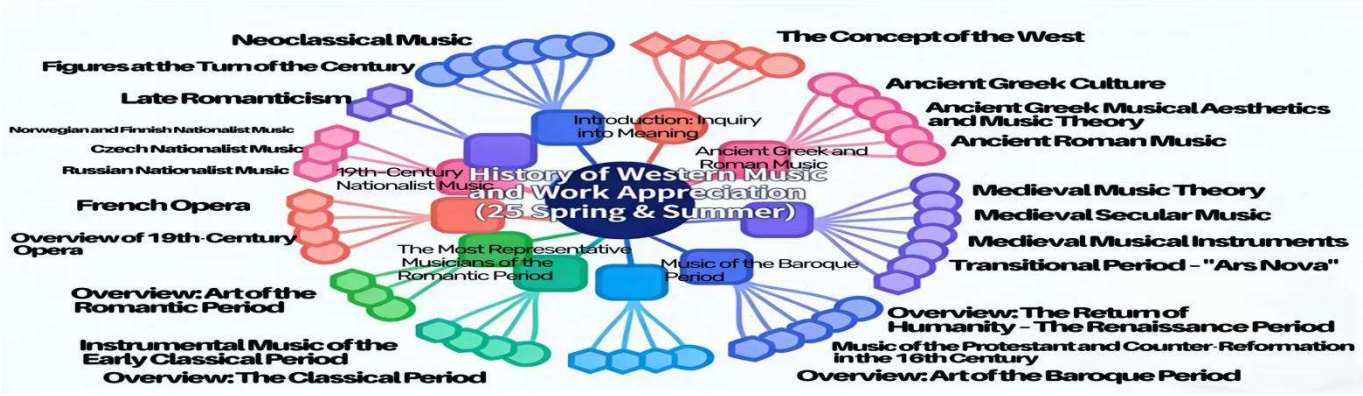


Figure 1. Circular diagram representation of the knowledge graph construction for the Western Music History and Appreciation course

In the practical application of constructing course knowledge maps, the initial step involves knowledge deconstruction and reconfiguration. The disciplinary knowledge system is disassembled into modular knowledge units, each further refined into specific knowledge points. By linking knowledge points to units and establishing inter-unit connections, the disciplinary logical relationships between knowledge points are systematically integrated. This forms hierarchical relationships between knowledge units and networked relationships among knowledge points. For instance, the knowledge unit 'Opera Reform and the Comic Opera Controversy' links to knowledge points such as 'Gluck and His Opera Reform', 'Characteristics and Development of Comic Opera', and 'Overview: The Classical Period'. Radiating annotations labelling "Progression" between this unit and the knowledge unit 'Origins and Early Development of Opera' clearly demonstrate the logical relationships among knowledge points. This forms a three-dimensional knowledge network, avoiding the excessively long logical chains that can result from branching expansions in mind maps. (See Figure 2)

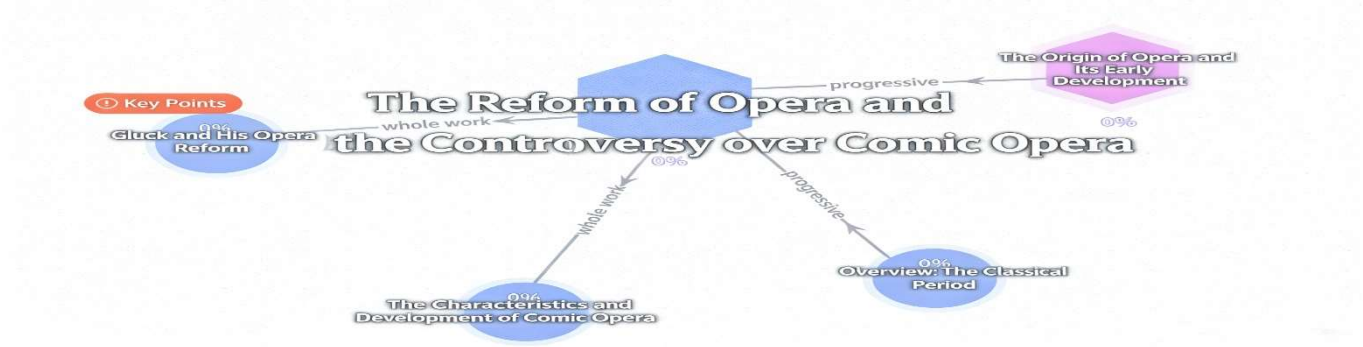


Figure 2. Three-dimensional Knowledge Network for the Unit 'Opera Reform and the Comic Opera Controversy'

According to sensory synergy principles, the greater the number of senses engaged in information gathering, the more effective perception becomes and the more robust the knowledge acquired. Knowledge graphs employ elements such as imagery, colour, and keywords to stimulate multiple sensory pathways in learners, thereby enhancing memory efficiency. Compared to purely textual narratives, knowledge presented through such graphs leaves a more profound impression on students. Moreover, through diverse knowledge representations and the structural properties of different diagrams, knowledge maps transform abstract 'historical logic' into intuitive 'visual models'. This assists learners in transcending linear thinking and establishing a deep, systematic understanding of music history. Additionally, online intelligent platforms can generate personalised learning pathways tailored to individual learning characteristics and needs – pathways optimised for each learner's maximum efficiency. (See Figure 3)



Figure 3. An Illustrative Example of Constructing a Problem Map for the Course on Western Music History and Music Works Appreciation

The problem map adopts a three-tiered architecture designed with a logical progression from macro to micro: 'global-level problems-conceptual-level problems-methodological-level problems'. Through sequential decomposition, it achieves a multidimensional presentation of the course's problem system. Global-level problems correspond to the overall scope of the course, conceptual-level problems focus on the conceptual breakdown of course content, while methodological-level problems provide process-oriented analysis of chapter-specific teaching content. This forms a clearly structured and interconnected problem system. This tiered problem design preserves the integrity of the course knowledge system while fostering problem-oriented learning through question-based activation of proactive inquiry. It enables learners to engage in deep knowledge construction through problem reflection, ultimately achieving educational objectives that progress from knowledge acquisition to problem-solving and culminate in competency development. (See Figure 4)

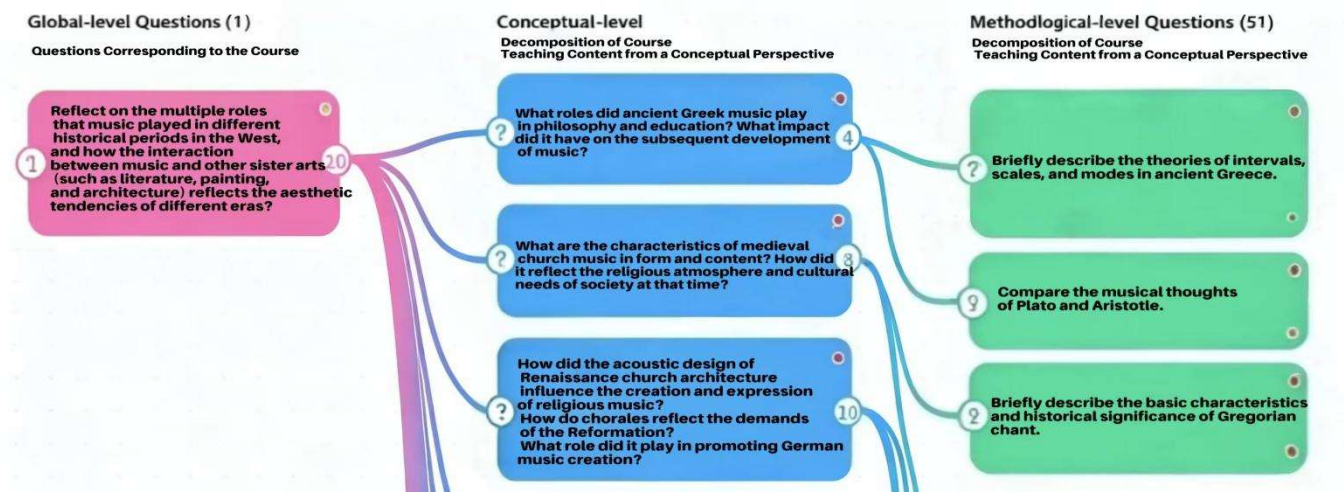


Figure 4. Example of Constructing a Problem Map for the Course on Western Music History and Appreciation

3.2. During Lessons: Constructing a 'Case-Linked Map'

With students having acquired foundational knowledge of Western music history prior to lessons, teachers and pupils can fully utilise class time for in-depth interpretation of works and probing inquiry into underlying issues. Centring on the work itself, they can radiate outwards to connect related knowledge points, forming a 'case-centred map'. Taking Beethoven's Ninth Symphony as an example, the central node of this 'case-centred diagram' is the work itself-the musical entity. Radiating outward from this core node are primary associations: the composer, compositional context, and formal structure. Further outward lie secondary associations: Beethoven's contemporaneous works, prevailing social ideologies, and instrumental evolution, progressively expanding in outward layers. This approach facilitates students' comprehensive understanding of Classical music during in-depth exploration of the work.[11-15]

Students may uniquely organise and present knowledge based on their own analytical interpretations, constructing personalised 'case-centred' knowledge maps. When mapping these knowledge networks, students must organise and analyse Western music history, deepening their grasp of key concepts while actively considering spatial arrangements and interconnections between nodes. This process encourages reflection on intrinsic relationships between knowledge points, reinforces understanding of the interconnected elements associated with musical works, and prevents viewing history as a fragmented collection of isolated facts. Instead, it fosters recognition of music's essence as an organically interconnected whole, enabling more comprehensive and profound comprehension. Simultaneously, students cultivate independent learning abilities and creative thinking through autonomous exploration of the Western music history knowledge system. For instance, they may

uncover connections between musical styles or develop novel interpretative perspectives on a composer's works.

Through work analysis and problem inquiry, teachers can guide students in collaboratively mapping knowledge diagrams. This process encourages students to voice opinions and pose questions, fostering exchange and discussion between teachers and students, as well as among peers. For instance, when analysing a specific work, students may propose divergent viewpoints based on individual interpretations, collectively refining the knowledge diagram's construction. This achieves dynamic knowledge generation and sharing, transforming the knowledge diagram into a collaborative outcome synthesising diverse perspectives. Moreover, the in-depth inquiry prompted by work analysis can nourish and refine the problem map, forming a logical closed loop: 'knowledge map → work analysis → problem inquiry → problem map → knowledge map'. This creates an interactive cycle where 'the knowledge map guides work analysis → the analytical process generates profound questions → integrated questions refine the map → which in turn enriches the knowledge map'[15-21].

3.3. Post-Lesson: Deepening Knowledge Maps and Feedback

The post-lesson phase constitutes a crucial extension where knowledge maps empower the flipped classroom. Students systematically review and dynamically refine the knowledge and problem maps constructed during pre- and in-class sessions via intelligent platforms. With the knowledge map's assistance, students can trace the logical connections between musical styles, composers, and works across different periods through multi-dimensional views ('tree map → ring map → network map'). For instance, linking the 'Classical Period' knowledge unit with points such as 'Haydn's symphonies' and 'Mozart's operatic compositions' reinforces the integrity of historical contexts. Simultaneously, the platform intelligently recommends reinforcement pathways for weak knowledge points based on individualised learning data (e.g., knowledge node click frequency, completion rates of knowledge and question maps, mastery of post-class exercises). For instance, students demonstrating insufficient grasp of 'French Opera' receive automated recommendations for relevant video analyses, supplementary readings, and targeted assessments, enabling a closed-loop learning cycle of 'identifying gaps – addressing deficiencies – achieving improvement'. Teachers, through a dynamic comprehensive evaluation system, analyse post-class learning behaviour data (such as homework accuracy rates and frequency of question submissions) to precisely identify collective knowledge gaps and individual learning needs. For instance, if most students demonstrate misunderstandings at the 'Major Genres of 20th-Century Modern Music' node, teachers can supplement with thematic micro-lessons or discussion tasks, guiding students to enrich their knowledge networks through additional audio examples and stylistic comparisons. Students may also creatively expand their existing knowledge maps based on independent post-class research, adding cross-era connection nodes to form personalised knowledge extension networks. This process not only strengthens knowledge transfer and application skills but also propels the evolution of knowledge maps from static to dynamic, truly realising a tripartite intelligent learning ecosystem of 'learning-assessment-revision'.

3.4. Dynamic Comprehensive Assessment System

This course employs a dynamic comprehensive assessment system, enabling students to monitor their learning progress and mastery of course content in real time with precision. They can then address any gaps to enhance their understanding. Utilising learning behaviour data, teaching staff can also analyse student progress and comprehension instantly, pinpointing areas requiring attention. This facilitates timely adjustments to teaching plans and priorities, thereby improving learning efficiency.

The comprehensive course assessment comprises five components: knowledge mastery, progress through learning objectives, assignments and quizzes, examinations, and offline performance. Utilising the Wisdom Tree digital platform, it accurately tracks students' online learning progress, pre-class test scores, post-class assignments, and the quality of group work and task completion, ensuring data authenticity and objectivity. For offline assessments such as group discussions and teaching demonstration activities, detailed assessment rubrics and evaluation criteria have been developed to guarantee consistent and coherent standards. This facilitates a shift from traditional, knowledge-centric assessment towards evaluating students' comprehensive competencies. This dynamic, holistic evaluation system overcomes the limitations of previous single-dimensional approaches focused solely on knowledge acquisition. It incorporates the depth of students' thinking, analytical skills, expressive abilities, creative capabilities, and collaborative competencies into the assessment framework, achieving comprehensive and objective evaluation. Simultaneously, the real-time nature of dynamic assessment enables both students and teachers to promptly identify knowledge gaps, thereby facilitating learning through evaluation.

4. Practical Outcomes and Reflections

Practice demonstrates that the knowledge graph-enhanced flipped classroom model significantly enhances students' systematic cognition, learning initiative, and comprehensive abilities, providing valuable insights for the digital transformation of musicology programmes.

4.1. Substantial Enhancement in Systematic Understanding, Increased Proactive Learning and Problem-Oriented Awareness

Following the implementation of the 'knowledge map + flipped classroom' model in the 'Western Music History and Appreciation' course at the School of Arts, Zhejiang Normal University, students demonstrated markedly improved systematic comprehension of the subject matter and significantly heightened learning motivation. Post-implementation surveys revealed that 71% of students identified the most prominent advantage of knowledge graphs as 'structured knowledge presentation'; 79% reported knowledge graphs as 'highly helpful' or 'somewhat helpful' for understanding music history contexts; and 75% rated the resource integration capabilities (e.g., content richness, accuracy, update frequency) of the knowledge graph platform as 'very strong' or 'quite strong'. Concurrently, the flipped learning model—combining pre-class self-directed study with in-class deep inquiry—stimulated students' critical

awareness. 83% reported their learning habits had 'significantly changed' or 'slightly changed'. Students proactively engaged in pre-class preparation, post-class extension activities, and online discussions, establishing a virtuous cycle of 'independent problem identification → collaborative classroom exploration → post-class practical verification' (see Figure 5).

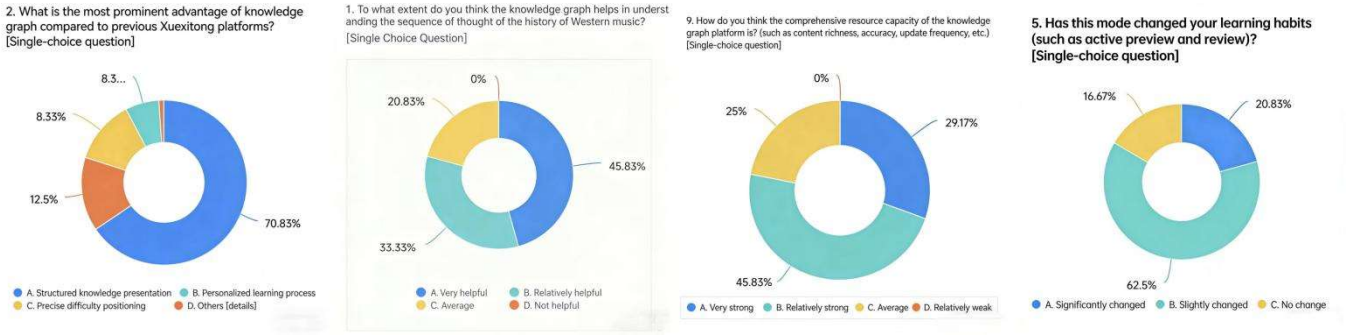


Figure 5. Circular Diagram of Survey Questionnaire Results

4.2. Innovation in Evaluation Systems Promotes Holistic Development

The dynamic comprehensive evaluation system transcends the limitations of traditional closed-book examinations. It integrates online learning data (such as knowledge map browsing duration and problem map completion rates) with offline practical performance (including group discussions and stage presentations) alongside end-of-term assessments. This approach enables multidimensional evaluation of students' knowledge acquisition, critical thinking abilities, and collaborative innovation skills. Survey findings indicate that 63% of students endorse incorporating platform metrics (e.g., learning progress, AI-assisted Q&A interactions) into assessment criteria, deeming this approach 'highly reasonable' or 'reasonable'. Furthermore, 75% report gaining clearer insights into their learning trajectory through the learning analytics module (covering mastery levels and performance data). (See Figure 6) This blended formative and summative assessment model shifts students from passive exam preparation towards proactive development, thereby fostering the growth of comprehensive competencies.

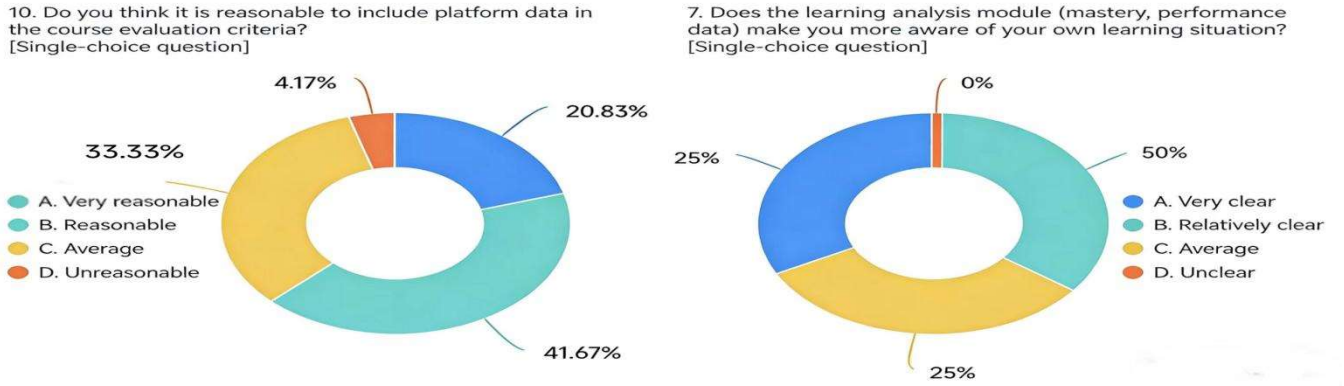


Figure 6. Circular Diagram of Questionnaire Results

4.3. Future Feasible Pathways

When teachers employ knowledge graphs to enhance flipped classroom teaching models, they may strengthen the structured support of knowledge graphs and interactive design throughout the entire teaching process. Educators can continuously optimise the interactive experience of knowledge graphs-for instance, by improving mobile compatibility and simplifying node association logic-while exploring hybrid Q&A models combining AI-powered responses with teacher verification to enhance accuracy in addressing complex music theory queries. Crucially, flipped classrooms and knowledge graphs demand heightened digital teaching competencies from educators. Through designing open-ended inquiry tasks and creating cultural contexts, teachers can guide students to deepen their aesthetic appreciation and critical understanding of musical culture during the construction and deconstruction of knowledge graphs. Teachers must transform their role from knowledge transmitters to learning facilitators, stimulating students' initiative to ultimately achieve the organic unity of 'knowledge transmission-aesthetic perception-cultural comprehension.'

5. Conclusion

In summary, the integration of flipped classrooms with knowledge maps provides robust support for transforming teaching paradigms in higher normal music education. By establishing a cognitive loop of 'pre-class exploration → in-class internalisation → post-class refinement,' this approach facilitates a shift from fragmented comprehension to systematic construction within the complex, temporally and spatially expansive field of Western music history. Students' structured cognitive abilities, learning initiative, and aesthetic critical awareness all demonstrate significant enhancement. This integrated approach not only addresses the longstanding challenge in higher normal education of prioritising knowledge transmission over structural guidance but also provides a practical model for effectively implementing

student-centred pedagogy in the classroom. The introduction of knowledge graphs renders abstract historical logic tangible and personalises dynamic learning pathways, propelling the classroom from content-intensive to cognition-driven learning. This embodies the educational principles of 'teaching guided by learning' and 'assessment promoting learning'.

Looking ahead, constructing new pedagogical models that integrate disciplinary characteristics with technological foundations is essential for implementing the digital education strategy and advancing the development of the 'new liberal arts.' Guided by the 'Education Powerhouse' strategy and the Digital Education Action Strategy, arts education-as a vital domain for enhancing students' core competencies and fostering cultural confidence-urgently requires intelligent, structured pedagogical innovation. This will enable a profound shift from mere knowledge transmission towards deepening cultural comprehension, cultivating aesthetic appreciation, and nurturing critical thinking skills. Leveraging knowledge graphs as an engine, and synergising elements such as flipped classrooms, intelligent assessment, and multimodal resources, will continuously expand the boundaries and depth of digital development in arts education. This will empower higher education in the new era to achieve the dual objectives of value leadership and quality enhancement.

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