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INDEX

S. No.	PAPER TITLE AND AUTHOR NAME	PAGE No.
1.	डॉ. लक्ष्मण सहाय की रंगमंचीय आलोचना दृष्टि	1
2.	Fuzzy Computational Analysis of Fuzzy hybrid structure	7
3.	CHOIR AND DEMOCRACY: THE COLLECTIVE POWER OF EXPRESSION	15

**डॉ. लक्ष्मण सहाय की रंगमंचीय आलोचना दृष्टि****रागिनी शर्मा****शोध- प्रपत्र****शोध छात्रा, माधव महाविद्यालय****ग्वालियर म.प्र.****Paper Received date**

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डॉ. लक्ष्मण सहाय ने ग्वालियर के कला प्रेमी राजा मानसिंह के नगर ग्वालियर में रहकर आलोचना विद्या को नयी दिशा प्रदान की, वे आजीवन मौलिक लेखन करते रहे, और मौलिक बौद्धिकता के लिए संघर्ष करते रहे। निबंध, काव्य और अन्य विधाओं का उन्होंने आलोचनात्मक लेखन किया परन्तु मुख्यतः उन्हें ख्याति रंगमंचीय आलोचना के क्षेत्र में प्राप्त हुयी, नाट्य आलोचना विषयक उनके विभिन्न शोधलेख नाट्य समीक्षा की विविध पत्रिकाओं में छपते रहे हैं। उन्हीं शोधपत्रों एक संकलन 'रंगकर्म और नाटककार' शीर्षक से पुस्तकाकार प्रकाशित हुई है। रंगमंच और नाट्यकर्म को लेकर डॉ. लक्ष्मण सहाय ने शोधात्मक तथ्य प्रस्तुत किये हैं।

“उन्होंने (भरत मुनि) ऋग्वेद से पाठ अंश लिया सामवेद से गीत का अंश, यजुर्वेद से अभिनय अथर्ववेद से रसों संग्रह किया ।” (1)

डॉ. सहाय की नाट्यकर्म विषयक आलोचनात्मक दृष्टि दो प्रकार की है। सैद्धांतिक और व्यावहारिक इनकी सैद्धांतिक आलोचना, नाट्य लेखन और रंगकर्म के प्रति आबद्ध है। तो दूसरे प्रकार की व्यावहारिक आलोचना में डॉ. सहाय ने विभिन्न नाटककारों के नाटकों का नाटकों के सैद्धांतिक और आलोचनात्मक अध्ययन किया है। वस्तुतः व्यावहारिक पक्ष की आलोचना का मूल आधार आचार्य भरत कृत नाट्यशास्त्र है, जिसे विद्वानों ने पंचम वेद की संज्ञा दी है। डॉ. सहाय ने नाट्यशास्त्र को आधार मानकर ही अपनी नाट्य आलोचना को परिणिति प्रदान की है।

डॉ. सहाय ग्वालियर के निवासी थे, इसलिए उन्होंने अपनी मातृभूमि के प्रति निष्ठा प्रस्तुत करते हुए ग्वालियर अंचल के रंग कर्म को प्रधानता दी, यह लेखक की अपनी जन्म भूमि के प्रति प्रेम को दर्शाता है।

जगन्नाथ प्रसाद मिलिन्द के नाटक मानसिंह कालीन बरई का मुक्ताकाशी मंच को अपनी दृष्टि से देखना, ग्वालियर के रंगमंच और रंगकर्म परम्परा को विश्लेषित करना तथा ग्वालियर के महाराज मानसिंह तोमर काल के रंगमंच को उद्घाटित करना डॉ. सहाय की अपनी विशेषताएँ हैं। इन्हीं आधारों पर डॉ. सहाय को आलोचनात्मक की दृष्टि से परखा जा सकता है।

सैद्धांतिक पक्ष: इसके अन्तर्गत नाट्य तत्व यात्रा: प्रकृति से वेद और वेद से नाट्यशास्त्र तक त्रिआयामी नाटक में नाटककार और नाट्यलेख, नाट्य-समीक्षा, रंग-संकेत का नाट्यलेख और मंच-प्रदर्शन में महत्व, नाट्य-प्रदर्शन में रंगदीपन का अवदान आदि अन्य सैद्धांतिक पक्ष का आलोचनात्मक मूल्यांक डॉ. सहाय द्वारा संपादित की गई है।

लक्ष्मण सहाय द्वारा नाट्य आलोचना में सैद्धांतिक एवं व्यावहारिक पक्ष के अतिरिक्त लोक नाट्य को भी अपनी आलोचना का विषय बनाया, लोक नाट्य के स्वरूप का वर्णन करते हुए डॉ. सहाय लिखते हैं- आबद्ध किया गया तो वे लोक नाट्य न रहकर शिष्ट नाटक हो जाएंगे और उन नाटकों में फिर लोकपन नहीं रहेगा।

"ग्राम जीवन में योग्य प्रशिक्षित रंग-निर्देशक भी नहीं पाये जाते हैं। ऐसे निर्देशक गाँव की अपेक्षा उन्नति प्रगति और विकास की सम्भावनाओं के कारण नगर में रहना, रंग निर्देशन करना, उचित समझते हैं। इसलिए वे नगर एवं महानगरों में स्थायी रूप से निवास करते हैं। निर्देशक समान गाँव में प्रायः कुशल अभिनेता भी नहीं होते हैं। अभिनेत्रियों के मिलने कारण का प्रश्न ही नहीं उठता। कारण यह है कि ग्राम वासी उतने आधुनिक और रीति-नीति परम्परा भंजक नहीं हैं, चाहे उनमें स्वतन्त्रता के उपरान्त कितना ही विकास क्यों न हो गया है। इसके बाद भी उनके रक्त में जमी परम्परावादी विचारधारा को आकाश से तारे तोड़ने की इच्छा करने के समान ही है।" (2)

ग्रामीण जन-जीवन के परिवेश को डॉ. सहाय ने लोकनाट्यों के आधार पर विश्लेषित किया है। परन्तु जो शास्त्रीय नाटक है, या नाट्य परम्परा है, उसके शास्त्रीय पक्ष को भी उन्होंने उद्घाटित किया है।

भरत के रस सूत्र -

विभाव, अनुभाव और व्यभिचारी संयोग रस भाव निष्पत्ति: के अनुसार रस की जो निष्पत्ति होती है। इस पर ही समूचे रस सिद्धांत का महल बड़ा हुआ है। यहाँ कालान्तर में दण्डी, भामह, रुद्रक एवं रूयैक आदि काव्यशास्त्रीयों ने यह प्रश्न उपस्थित कैसे किया कि रस निष्पत्ति कैसे होती है ? क्या प्रेक्षा को भी उसी भाव का अनुभव होता है। जिस दृश्य मंचन किया जा रहा है, और यदि दर्शक उस भाव को आत्मसात कर रहा है, तो क्या पात्र भी उस दशा को प्राप्त कर लेता है। डॉ. लक्ष्मण सहाय ने अपने आलेख त्रि-आयामी नाटक में नाटककार का परकाया प्रवेश में इस तथ्य पर गंभीरता से चिंतन किया है। वे लिखते हैं कि “भरतमुनि ने नाटक को वस्तु नेता और रस तत्व के माध्यम के कारण त्रि-आयामी कहा है।”

उन्होंने इन्हीं तीनों में नाटककार के परकाया प्रवेश को विश्लेषित करते हुए लिखा है। " नाटककार कहाँ, किस प्रकार की ध्वनि, गायन, नृत्य एवं संगीत का किस स्थान पर प्रयुक्त करना उचित समझता है, वह उनके प्रयोग का संकेत करता है। फलतः रंग- मंचन के समय नाटककार के अनुसार ध्वनि, संगीत का गायन, नृत्य समावेश निर्देशक ध्वनि, संगीत, नृत्य अभिकल्पकों से उनको कराता है। यह सब नाटककार के अनुसार ही होता है- संप्रयोजन और सरंजक नाटककार नाटक के लेखन- प्रदर्शन तक प्रत्यक्ष-परोक्ष रूप में परकाया प्रवेश क्रिया की सिद्धि से उपस्थित रहता है, और उसकी यह उपस्थिति ही नाट्य मंचन में संगीत की अनिवार्यता, हिन्दी नाटक और रंगमंच: एक यात्रा आदि निबंध लेखक की नाट्य आलोचना सैद्धांतिक पक्ष को स्पष्ट करते हैं।

डॉ. सहाय का मानना है कि नाटकों के तत्व प्रकृति जन्य है। प्रकृति से उनका आगमन वेदों में हुआ और वेद से ही भरतमुनि ने अपने ग्रंथ नाट्यशास्त्र में समाहित किया आचार्य भरत ने केवल प्रदान वेद तत्व को ही मान्यता प्रदान नहीं की अपितु लोक एवं लोकधर्मता को भी उन्होंने प्राथमिकता भी दी है-

“लोकधर्मो भक्त्वेन्याट्यधर्मो तथापरा ।

स्वाभावो लोकधर्मो तु विभावो नाट्य वेद हि ।। (3)

डॉ. सहाय मान्यता प्रदान करते और इसी से प्रेरित होकर इन्होंने लोक - नाट्य के विश्लेषण को भी अपने अध्ययन का विषय बनाया है। हिन्दीभाषी प्रांतों में ग्रामीण रंगमंच, लोक-नाट्य जात्रा तथा हासिये के बाहर खोड़या लोकनाट्य जैसे आलोचनात्मक निबंधों की सृष्टि की सच तो यह है कि लोक के आभाव में नगर नाटको की संकल्पना नहीं की जा सकती है।

लोक का सीधा संबंध प्रकृति से है। डॉ. सहाय लिखते हैं कि आदिम प्रकृति तदयुगीन मानव द्वारा सप्रेक्षित बोलचाल अभिनय, आंगिक, भंगिमा, उत्पन्न ध्वनि, संगीत और अव्यवस्थित स्वर से कड़वे, चिरपिरे, नुनखरे रस को उस समय के मानव ने ऋचाओं में अभिव्यक्त किया है।

" नाटककार नाटक के लेखन-प्रदर्शन तक प्रत्यक्ष-परोक्ष रूप में परकाया - पवेश-क्रिया की सिद्धि से उपस्थित रहता है और उसकी यह उपस्थिति ही नाटक के प्रदर्शन द्वारा प्रेक्षक अर्थात् रसभोक्ता का रसार्द्र करती है तथा प्रयोजन की पृष्टि भी करती है। (4)

नाट्य प्रदर्शन में रंग दीपन का अवदान विशिष्ट महत्व रखता है। रंगमंच पर उचित समय पर उचित प्रकाश का व्यवस्थापन भावों को उद्दीप्त करता है। रंगों का कम या अधिक करना समूचे रंगमंच के प्रवेश कर के व्याख्यायित कर देता है। डॉ. सहाय लिखते हैं-

“रंगदीपन अभिकल्पक का रंगलोक के राजदीपन प्रति महत्वपूर्ण दायित्व है- अभिनेता और पृष्ठभूमि के मध्य सम्बन्ध स्थापित करना। वह अभिनेता या वस्तु - विशेष पर प्रकाश डालकर उन्हें विशेष और महत्वपूर्ण संप्रयोजक बनाता है। अभिनेता की भाव-भंगिमाओं की सूक्ष्मताओं को प्रेक्षक तक पहुंचाने का कार्य-निष्पादन अभिकल्पक रंगलोक के माध्यम से ही करता है। इससे वह प्रकाश और अंधकार को सन्तुलित करता है। “इन सभी आवश्यकताओं, उपयोगिताओं तथा प्रभावोत्पादकताओं के कारण नाट्य-प्रदर्शन में रंगदीपन की विशेष आवश्यकता पड़ने लगती है, और वह भी विविध वर्णों में है। (5)

लक्ष्मण सहाय की व्यवहारिक आलोचना दृष्टि रंगमंच सैद्धांतिक आलोचना के साथ-साथ सहाय नाटक के व्यावहारिक पक्ष पर भी दृष्टिपात किया है। व्यावहारिक आलोचना के अन्तर्गत इन्होंने 'मिलिन्द का नाटक ' 'प्रताप प्रतिज्ञा' : मेरी दृष्टि में, रामकुमार वर्मा के अन्तर्गत नाट्य साहित्य में सांस्कृतिक स्वरूप, लक्ष्मी

नारायण लाल के नाटको में, भारतीयता, हबीब तनवीर और दो लोक कथाश्रित नाटक, दयाप्रकाश सिन्हा के नाट्य साहित्य में दृश्यबंध के लिए, युद्ध की अनिवार्यता का दास्तावेज- 'रक्त अभिषेक' आदि लेखों में इनकी व्यवहारिक आलोचना परिलक्षित होती है। व्यवहारिक आलोचना के मापदण्डों को ये निबंध आति पूर्ण करते हैं। अपने व्यावहारिक निबंधों में पहले संबंधित नाटक अथवा नाटककार संक्षिप्त परिचित देते हैं। फिर उनके प्रदेय को रेखांकित करते हैं। " हबीब तनवीर ने देहांगो की क्रिया-प्रतिक्रिया के अनुरूप ही रंग-संकेत प्रस्तुत किये हैं, जिनसे निर्देशक का अभिनय - क्षेत्र में मार्ग प्रशस्त होता है।" विवेच्य नाटक के रंग-संकेत अभिनेता की मनः स्थिति का बोध करते हैं तथा अभिनेता को आंगिक, भंगिमायें करने में सहयोगी है।

"नाटक का शिल्प - गठन संवेदना एवं कथानुरूप तथा पात्रानुसार है, सशक्त है। अपनी इसी गुण और विशेषता के कारण यह नाटक अनेकशः बार-बार मंच पर खेला जा सका है और वर्तमान, भविष्य में भी मंचित किया जा सकता है। इस नाटक में पंजीयक और अनाज लेने वाली भीड़ के अतिरिक्त मूल पात्र सोलह हैं, जिनमें चौदह पुरुष पात्र और दो नारी पात्र हैं। वर्तमान में भीड़ दिखाने के दृश्य आसान हो गये हैं, इसलिए प्रदर्शन में अनाज लेने के लिए उमड़ी भीड़ को प्रदर्शित किया जा सकता (6)

नाटकों की कथावस्तु, सामाजिक, राजनैतिक, व्यंगात्मक, धार्मिक पौराणिक एवं ऐतिहासिक कोई भी हो सकती है। नाटक की प्रकृति जैसी होती है उसके सहजीकरण के लिए भाषा का होना आवश्यक है। डॉ. सहाय नाटककार के नाटकों के विधानों को मौलिक दृष्टि से उद्घाटित करते हैं। हबीब तनवीर के नाटक 'बाहदुर कलारिन के विश्लेषण का एक दृश्य' "बाहदुर कलारिन नाटक में बीस पात्र हैं, जिनमें बारह पुरुष और आठ महिला पात्र हैं। इस लोक-कथाश्रित नाटक में लोकगीत-संगीत और नृत्य मनमोहक सामंजस्य है। हबीब तनवीर ने लोककथा को कल्पना माध्यम से इस दृश्यों में नियोजित किया है। उन्होंने अंक और उसके दृश्यों के सिद्धांत का प्रयोग - विन्यास में नहीं किया है। (7)

पुरानी परिपाटी अंक - दृश्य को तोड़कर नये दृश्य-सिद्धान्त का अनुगमन किया है। हबीब तनवीर नाटक को प्रभावशाली और हृदयग्राही बनाने के लिए नित नये प्रयोग, नये सिद्धान्तों की खोज करते रहे हैं, जैसा उनके समकालीन नाटककार करते रहे हैं। नाट्य - कथा के विकास पात्रों की मनोदशा, अंग भंगिमा के संचालक उनके सम्वाद छोटे होने पर भी प्रेक्षक को झकझोरने, गुदगुदाने, भाव विभोर करने और सोच विचार कराने



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वाले हैं। नाटक की भाषा संवादों को असीम क्षमता और ऊर्जा प्रदान करती है। सम्पूर्ण नाटक की भाषा छत्तीसगढ़ी है। नाटककार ने 'बहादुर कलारिन' के माध्यम से छत्तीसगढ़ी भाषा से सम्पूर्ण देश-विदेश को परिचित करा दिया है। इसमें लोकभाषा का अनुपम प्रयोग है। नाटक के रंग-संकेत अभिनेताओं की मनोदशा और मनोदशानुरूप अंग संचालन को दिशा प्रदान करते हैं।

निष्कर्ष -

डॉ. लक्ष्मण सहाय ऐसे समालोचक रहे हैं, जिनका रंगमंच और नाटक के प्रति नवोन्मेष रहा है। डॉ. सहाय ने नाटकीय आलोचना में नये-नये प्रयोग किये हैं। आलोचना के दोनों पक्षों सैद्धांतिक और व्यावहारिक को इन्होंने गहराई से हृदयांग्य किया है। नाटकीय आलोचना के क्षेत्र में इनका कार्य अप्रतिम है। इसके अतिरिक्त आपने हिन्दी नाट्य साहित्य में लोक - नाट्य की भूमिका का भी निर्धारण किया है।

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**Fuzzy Computational Analysis of Fuzzy hybrid structure**

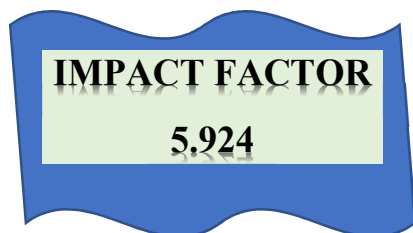
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**ABSTRACT**

In this paper, we explore the application of fuzzy topological indices to the fuzzy tadpole graph, a hybrid structure that combines the cyclic and path-like components within a fuzzy framework. We compute and analyze several key fuzzy indices, including the fuzzy Zagreb indices, fuzzy Randić index, fuzzy Harmonic index, fuzzy Sombor index, fuzzy Misbalance Prodeg index, and fuzzy Nirmala index, to gain a comprehensive understanding of the graph structural and topological properties.

Our results reveal how fuzzy indices provide deeper insight into the graph connectivity and stability, especially in scenarios where traditional (crisp) indices may be inadequate. These findings have potential applications in domains such as complex network analysis, molecular chemistry, and systems with inherent uncertainty.

Keywords:- Framework, Comprehensive, Properties, Especially

Graph theory is the basic concept in the study of complex systems, providing a mathematical framework for simulating links and interactions in disciplines such as computer science, chemistry, biology, and social science. Topological indices (TIs) are numerical variables linked with a graph's structure that capture its fundamental attributes. These indices are rapidly employed in fields ranging from network analysis to molecular property prediction in chemical informatics.



Traditional TIs are typically used for crisp networks in which edges are either present or absent, leaving no space for ambiguity. However, many real-world systems are characterized by uncertainty, imprecision, and ambiguity, which crisp graph models cannot portray. To address this restriction, fuzzy graph theory extends traditional graph notions by allowing both edges and vertices to have varying degrees of membership, reflecting the structure's inherent ambiguity. Fuzzy TIs are a natural extension of classical indices in this context, allowing for a more refined analysis of graph topologies with connections that are not strictly binary but vary in strength. These indices are especially useful when the relationship between entities is unclear or when it's necessary to account for ambiguity in interaction strengths.

The purpose of this work was to look into fuzzy TIs for tadpole graphs. The tadpole graph is a form of graph in graph theory that consists of a single cycle (the “body” of the tadpole) and a single path (the “tail” of the tadpole) connected to the cycle. Our study seeks to assess the behavior of fuzzy TIs when applied to these graphs, specifically how these indices represent the structural nuances given by fuzziness. We wish to better grasp the benefits of fuzziness in graph analysis by comparing indices in both crisp and fuzzy contexts. This paper adds to the increasing body of research in fuzzy graph theory and its application by providing fresh insight into the structural analysis of complex systems with uncertainty as a basic component.

A graph is a $\mathcal{G}$ ordered pair $(\mathcal{G} = (\mathcal{V}, \mathcal{E}))$ if:

- $\mathcal{V}$, a set of vertices (or nodes),
- $\mathcal{E}$, a set of edges, The points or vertices are the basic units of the graph, while the edges are the connections between them.

According to crisp graph theory, the number of edges incident to a vertex u in a graph is its degree. The degree of a vertex u , denoted by $\deg(u)$, in a graph $\mathcal{G}$ is usually explained as

$$|\mathcal{G} = (\mathcal{V}, \mathcal{E})|$$



$$\deg(u) = |\{e \in \mathcal{E} \mid u \in e\}|,$$

Graph theory is the study of graphs, which are mathematical structures that represent pairwise relationships between things. Leonhard Euler, who solved the famous Königsberg bridge problem in 1736, is credited with pioneering graph theory. Euler's work laid the groundwork for graph theory, formulating the concept of a graph as a collection of vertices connected by edges.¹ Fuzzy graph theory is an extension of classical graph theory that covers situations in which interactions between entities are ambiguous, imprecise, or unclear. In 1965, Lotfi A. Zadeh combined fuzzy set theory with graph theory to describe edges in a graph with varying degrees of membership instead of binary (0 or 1) values. This paradigm is particularly useful in areas with uncertain linkages, such as the social sciences, biology, and decision-making processes.

Fuzzy graphs were first introduced by Arthur Rosenfeld in 1975. Rosenfeld's seminal work used fuzzy sets to graphs, allowing each edge to have a degree of membership ranging from 0 to 1. Following Rosenfeld's work, the researchers investigated fuzzy graph operations, such as connectedness, matching, and colorability. Their findings are regarded as critical to the future development and use of fuzzy graph theory. Pal reviewed segmentation techniques that laid the groundwork for using fuzzy models in image analysis, supporting the role of fuzzy theory in handling uncertainty relevant to our fuzzy graph approach. Shukla et al. demonstrated fuzzy decision-making in supply chain, showing how fuzzy logic effectively manages complex, uncertain systems, which aligns with our use of fuzzy indices in structural graph analysis. Prabusankarlal et al. highlighted fuzzy-based methods in breast cancer diagnosis, illustrating how fuzzy models can aid in analyzing uncertain and imprecise data similar to fuzzy graph applications in network modeling. TIs, which are numerical values derived from the structure of a graph, are used to evaluate and classify various molecular structures and network features.



These indices offer a significant improvement in graph theory, merging mathematical and chemical principles to provide useful modeling and analysis tools. TIs are numerical indices generated during the graphing process that are used to classify and investigate many features of molecular structures in chemistry and networks. These indices are a significant improvement in graph theory, combining notions from mathematics and chemistry to give a useful tool for modeling and analysis.

In 1947, a researcher named Harold Wiener created the concept of TIs. Wiener introduced the first topological index, Wiener index, when he was working on the boiling points of paraffin. To find the Wiener index, sum the distances between all of the graph's vertex pairs.² This index was initially used to investigate molecular characteristics and has since become one of the most often used indices in chemical indices in chemical graph theory. The Zagreb indices were among the earliest TIs developed to describe molecular structures in chemistry. The degrees of the graph's vertices are used to define the traditional first and second Zagreb indices, which are widely employed in quantitative structure-activity relationship (QSAR) research. Gutman and Trinajstić (1972)³ were the first to apply these indices to fuzzy graphs, establishing topological index theory.

The authors evaluated the *F*-index, a topological index based on node degree, as well as the molecular descriptor. Mondal et al. studied various TIs based on neighborhood degree. TIs are widely employed in chemical and spectral graph theory, network theory, and molecular chemistry. Given their widespread use in crisp graphs, researchers are also investigating TIs in fuzzy graphs. In, Uzma et al. investigated and applied TIs in cybercrime. Degree-based TIs to analyze extremal values of benzenoid structures are studied in, whereas Kalathian discussed distance-based TIs in. In, a comprehensive overview of the Randić index is provided.

The application of standard TIs of fuzzy environments has opened up new possibilities for studying graphs with nonbinary links. Several TIs have been developed to capture various components of graph structure in the presence of uncertainty. Initially, experts focused on using standard TIs for



fuzzy graphs, such as the Wiener, Randić, and Zagreb indices. As part of this technique, proper fuzzy representations for concepts like degree and distance were created. Aside from enhancing traditional indices, researchers developed entirely new fuzzy TIs to represent the distinct characteristics of fuzzy graphs. These indices typically aggregate the fuzzy memberships of vertices and edges to get a scalar value that represents a specific topological characteristic.

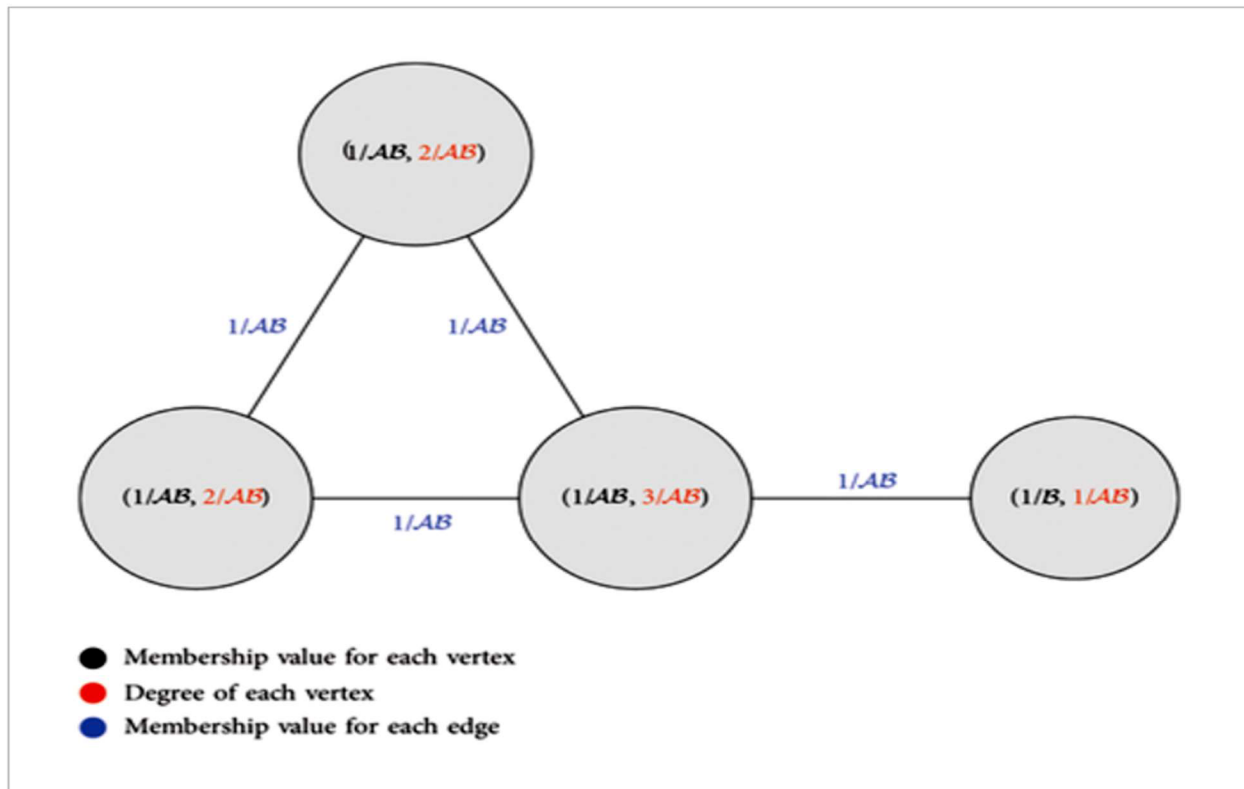
Kalathian et al. introduced degree-based TIs for fuzzy graphs in. Islam and Pal studied the first fuzzy Zagreb index and presented results for various fuzzy graphs, such as fuzzy path graphs, fuzzy cycle graphs, fuzzy star graphs, and fuzzy subgraphs. They also provide a technique for deciding which employee in a corporation is the most competent through multicriteria decision-making (MCDM), which takes advantage of fuzzy graphs' first Zagreb index. Poulik et al. developed the Randić index to analyze bipolar fuzzy graphs in. Akram et al. devised and applied the Randić index to bipolar fuzzy cycle graphs. Kalathian in used the fuzzy F index for fuzzy graphs to analyze railway crimes in India and compared it to three other TIs. In, researchers studied the fuzzy extension of TIs and found it useful for networks with unknown connections and fuzzy graphical structures. ZS Mufti formed the fuzzy Misbalance Prodeg index in and used it for MCDM. The fuzzy Sombor index has been examined in with applications in trade flows overseas.

Recent contributions have emphasized the importance of fuzzy graph indices in modeling uncertainty in networks and systems. Akram and Dudek presented fuzzy soft graphs for decision-making⁴, while Rashmanlou and Pal introduced new indices within intuitionistic fuzzy graphs⁵.

Similarly, Pal explored distance-based indices in q -rung orthopair fuzzy graphs, a generalization suitable for complex uncertainty modeling, and applications in molecular chemistry have also been analyzed using fuzzy TIs, and spectral approaches have recently been developed to enhance structural analysis. Mondal et al. applied TIs to model and evaluate chemical compounds used in the treatment of COVID-19, illustrating the practical importance of these indices in drug development and molecular chemistry.

In this study, we provide a fuzzy alternative to standard TIs for fuzzy tadpole graphs. We examine fuzzy versions of well-known indices like the Zagreb index, Randić index, Harmonic index, Sombor index, Misbalance Prodeg index, and Nirmala index. These indices are customized to reflect the properties of graph types in a fuzzy context. This work attempts to better understand fuzzy tadpole graphs and how to use them by developing and assessing fuzzy TIs. The findings provided here shed fresh light on the structural analysis of fuzzy tadpole graphs, opening the door to future research and practical application in a wide range of fields.

Parameter	Description	Role in graph construction
$\mathcal{A}$	Number of vertices in cycle $C_{\mathcal{A}}$	Forms the cyclic part of the fuzzy tadpole graph.
$\mathcal{B}$	Number of vertices in path $P_{\mathcal{B}}$	Forms the linear path attached to the cycle.
$T_{\mathcal{A},\mathcal{B}}$	Fuzzy tadpole graph with total $\mathcal{A} + \mathcal{B}$ vertices	Combines $C_{\mathcal{A}}$ and $P_{\mathcal{B}}$ at one vertex.



Conclusion

This study investigates the application of fuzzy indices on the fuzzy tadpole graph, providing new insights into its structural and topological properties. By analyzing indices such as the fuzzy Zagreb index, Randić index, Harmonic index, Sombor index, Misbalance Prodeg index, and Nirmala index, we have derived precise formulas that capture every aspect of the fuzzy tadpole graph in terms of its parameters and . We found and simplified explicit formulas for numerous fuzzy TIs of the fuzzy tadpole graph. These formulas provide a full understanding of how the graph's structure influences these indices, enabling further investigation and comparison with other graph types.



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Future research can explore the extension of these fuzzy indices to more complex graph structures, such as fuzzy barbell, helm, or triangular snake graphs. Additionally, incorporating advanced fuzzy logic frameworks like intuitionist, Pythagorean, or q-rung fuzzy models could yield even deeper insights. Application-based studies in fields such as molecular chemistry, social network analysis, and decision support systems may also benefit from these developments.

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5. famous Königsberg bridge problem in 1736

**CHOIR AND DEMOCRACY: THE COLLECTIVE POWER OF EXPRESSION****Özlem ONUK NATONSKI****ABSTRACT**

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This study approaches choral music not merely as an aesthetic practice but as a participatory space where social bonds are reinforced and democratic values are enacted. Grounded in principles of social-emotional learning, choral environments foster empathy, collaboration, and self-confidence skills essential for democratic life. Multicultural and inclusive choral projects, particularly those involving migrants and marginalized individuals, serve as platforms for belonging and civic engagement. Using a qualitative review methodology, the study highlights that singing together is not only a musical activity but also an ethical and socio-political practice.

Key Words: Choir, democracy, singing together.**IMPACT FACTOR****5.924****Introduction**

In the 21st century, democracy must be reconsidered not merely as a political system, but as a relational practice embedded in everyday life, shaped through affective experiences, cultural participation, and ethical responsibility (Giroux, 1994). As public spaces contract and social bonds weaken under the pressures of individualism, there is an urgent need to reimagine democratic life



in micro-social contexts. One such context is the choir an aesthetic yet deeply social formation in which individuals negotiate presence, difference, and shared meaning through collective voice.

This study proposes that choral singing constitutes a micro-democratic space, where individuals maintain their distinct identities while contributing to a pluralistic sonic whole. Rather than suppressing voices, the choir integrates them into a polyphonic structure that models the tension and possibility between unity and diversity. Grounded in the values of participation, empathy, equality, and mutual responsibility, choral practice becomes a site where democratic ideals are not only symbolized but *enacted*.

Framed through the lens of ethical relationality, the choir offers more than a musical experience. It functions as a living, pedagogical environment in which civic virtues such as listening, cooperation, self-regulation, and collective decision-making are cultivated. Whether through repertoire co-selection, non-hierarchical leadership, or participatory rehearsal methods, the choral space serves as both a metaphor and a material infrastructure for democracy.

Drawing upon interdisciplinary literature in music education, aesthetic theory, political philosophy, and cultural studies, this study positions choral music not only as a form of vocal

philosophy, and cultural studies, this study positions choral music not only as a form of vocal

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training but also as a practice of cultural citizenship. Through the convergence of sonic, emotional, and ethical dimensions, the choir emerges as a transformative space where the democratic potential of art is realized in real time, voice by voice, breath by breath.

Research Aim

This study aims to reconceptualize choral music as a social practice in which individual voices are experienced within a collective structure in an egalitarian and transformative manner, emphasizing its role in democratic participation, ethical responsibility, and a sense of belonging.

Method

This study is a qualitative literature review that considers the relationship between choral music and democratic values. It systematically analyzes national and international academic sources in the fields of musicology, music education, aesthetic theory, political philosophy, and cultural



studies. Rather than collecting empirical data, the study offers a critical and theoretical reinterpretation of existing literature through content analysis.

Participatory Performance and Cultural Cohorts² in Choral Practice

Participatory performance refers to musical expressions in which the distinction between performer and audience dissolves, allowing all participants to engage actively in the shared act of music-making. In such contexts, artistic excellence is secondary to communal inclusion, shared experience, and collective vocal production. Choirs embody this model by providing a space where both individual voices and collective harmony coexist. Each voice is heard, yet rather than dissolving into anonymity, it interacts with others to form a cohesive whole. Thus, choral music functions not only as an aesthetic form but also as a social model that reflects communal participation and relational harmony (Turino, 2008; Small, 1998).

The concept of cultural cohorts describes groups of individuals who share common values, practices, and musical preferences, forming a collective identity through musical participation. Choirs offer a fertile ground for such cohorts, facilitating emotional resonance and coordinated action. The shared rhythms, breath, and sonic alignment create a sense of unity that enables choirs to serve as agents of social cohesion. When participatory performance is considered alongside cultural cohorts, choral music emerges as a vital medium for expressing social belonging, mutual interaction, and collective agency (Turino, 2008).

²The term “cultural cohorts” is used here as a concept developed by Thomas Turino within the context of music sociology. According to Turino, cultural cohorts are communities formed by individuals who share similar musical preferences, lifestyles, or values—regardless of whether they come from the same ethnic or geographical background—but who identify with the same types of music. This concept refers to temporary or lasting collectives through which individuals construct their cultural identities via specific musical practices. For instance, a gospel choir, an LGBT+ choir, or a diaspora-based migrant choir can serve as examples of such cohorts. These groups need not share a common language or religion; rather, what brings them together is a shared sensory, emotional, and identity-based space made possible through musical practice (Turino, 2008).

**Society and Harmony: Philosophical Foundations**

The concepts of society and harmony have long served as foundational frameworks for understanding the relationship between the individual and the collective, dating back to Ancient Greek philosophy. Harmony is not merely a musical term but also a political and ethical principle. It refers not to the suppression of difference, but to the integration of diversity into a meaningful and balanced order. This understanding directly parallels the structure of choral music: each vocal part is distinct yet complementary; none forms a complete melodic whole on its own, but together they create coherence and meaning (Plato, 2004; Aristotle, 2013).

Such a perspective envisions a social model in which individuals retain their intrinsic value while contributing to the collective. The choir, through its sonic harmony, becomes a metaphor for a micro-society where individual freedom is inextricably linked to social responsibility. Ancient philosophical thought thus finds concrete expression in the choral experience, generating a semantic field that extends from aesthetics to politics. In this sense, the choir functions both as a site for cultivating individual virtue and as a structural model for a harmonious community (Aristotle, 2013).

Is the Choir Oppressive or Liberating?

Historically, the choir has functioned both as a model of togetherness and as a disciplinary apparatus. Consequently, approaches to choral music have ranged from viewing it as a space for social bonding to critiquing it as a form that suppresses individuality and reinforces authoritarian structures. Due to its emphasis on discipline, order, and authority, some theorists have argued that choral practices may hinder individual freedom of expression and reproduce a passive model of citizenship (Adorno & Horkheimer, 1997).

However, choral practices also hold emancipatory potential when guided by alternative models of leadership and pedagogy. In settings where the conductor acts not as a strict director but as a facilitator, where decision-making is shared and creativity is encouraged, the choir becomes a space where individuals can find their own voices and engage in meaningful dialogue with others. This positions choral music not only as a structural phenomenon but also as an ethical and political practice. Thus, depending on how it is organized and enacted, the choir may assume either a repressive or a transformative role. This ambivalence necessitates a critical reconsideration of choral music through a reflective and nuanced perspective (Adorno & Horkheimer, 1997).



As Phelan (2018) notes, singing within ritual practices entails not merely belonging to a community, but actively participating in its symbolic world. Rather than passive involvement, ritual singing shaped through bodily resonance, temporal synchrony, and tacit meaning-making transforms choral participation into a liberating and transformative experience.

Contemporary approaches in choral pedagogy help articulate the structural foundations of this transformation. Choir environments designed around Social and Emotional Learning (SEL) principles support not only musical skill development but also democratic competencies such as critical thinking, empathy, collaboration, and self-confidence (McNickle & Morris, 2022; Bıçakçı & Apaydın Demirci, 2022). When individuals are encouraged to claim ownership of their own voices within pedagogical freedom, the choir becomes not merely a space for organizing sound but a site for identity formation and self-efficacy (Garnett, 2017).

In this context, while Adorno's critical perspective on the choir retains its relevance, today's choral practices are being redefined through individual-centered and participatory models. This new vision of the choir shifts from rigid authoritarianism to horizontal relationships, and from technical discipline to emotional and ethical resonance. Yet, such potential is contingent upon how the choir is organized. As Adorno warned, authoritarian leadership structures and expectations of mechanical conformity can stifle the individual's critical voice. Therefore, a truly democratic choir must interrogate not only *who* sings together, but *how* they sing together (Adorno, 1997).

Choir as a Micro-Democracy: Embodying Democratic Values Through Collective Musicking

Choral singing offers more than an aesthetic experience it represents a lived model of participatory democracy. Within the structure of the choir, each individual voice contributes to a shared sonic outcome without being silenced or dominating. This polyphonic interaction embodies key democratic principles such as equality, reciprocity, empathy, and shared responsibility. As such, the choir becomes not merely a musical ensemble but a micro-society where active citizenship is practiced through relational listening and co-creation (Hawkins, 2024).

The concept of *micro-democracy* suggests that democratic values are cultivated not only in political institutions but also in everyday cultural practices. Choirs enact this principle by enabling individuals to express their voices while remaining attuned to others. No single voice overrides; instead, harmony emerges from mutual responsiveness. This structural balance fosters civic competencies including cooperation, deliberation, and respect for difference (Woodford, 2005). Choral settings thus function as pedagogical environments where the foundations of democratic life are rehearsed and internalized.



In the choir, participation is not solely physical; it is also emotional and cognitive. Through synchrony in rhythm, breath, and tone, singers engage in a collective act of meaning-making that strengthens their sense of social belonging. This resonance both sonic and affective creates a platform for mutual recognition and civic awareness (Small, 1998; Clift & Hancox, 2001). The embodied nature of choral singing transforms abstract democratic ideals into tangible experiences of co-presence and responsibility.

The leadership structure of the choir also plays a decisive role in shaping its democratic potential. When conductors adopt a facilitative approach encouraging distributed decision-making, repertoire co-selection, and interpretive openness the choir evolves into a participatory space rather than a hierarchical system. In this model, musical learning aligns with ethical and civic formation, promoting emotional intelligence, reflective listening, and the capacity for collective negotiation (Jordan, 2022; McNickle & Morris, 2022; Garnett, 2017). Here, the music educator acts less as a director of outcomes and more as a mediator of shared process.

Moreover, choral practice facilitates inclusive encounters among individuals from diverse social, generational, and cultural backgrounds. When implemented within socially responsive frameworks, choirs support identity negotiation and community-building. Especially in multicultural or intergenerational choirs, participants often report increased empathy, mutual understanding, and a reduced sense of social isolation (Harley, 2017). These dynamics align directly with the aims of a pluralistic and inclusive democracy.

In sum, choral singing not only mirrors but enacts democratic culture. It affirms the political importance of collective voice, shared listening, and aesthetic collaboration. Within the choir, democratic values are not simply taught they are experienced, embodied, and reimagined through the act of musicking together.

Choir and Identity Formation

Choral music is not merely the unification of voices; it is a powerful social practice that mediates processes of identity construction. As one of the emotional grounds where social belonging is cultivated, the choral environment enables individuals to define themselves on both individual and collective levels. Musical identity is shaped through recognizing, developing, and integrating one's voice in harmonious interaction with others. This process entails more than musical competence; it is a holistic experience that incorporates the social and emotional dimensions of identity (Ahlquist, 2006).



By bringing together individuals from diverse backgrounds across age, class, ethnicity, belief, or gender the choir becomes a space where difference is negotiated and transformed through shared musical production. In this polyphonic setting, individuals not only express their own voices, but also learn to listen, understand, and respond ethically to the voices of others. Identity thus emerges not merely as an internal construct but as the outcome of an ongoing process of collective negotiation (Bithell & Hill, 2014).

When viewed through the lens of performative social identity, singing in a choir becomes more than a musical act; it is a site where a sense of "we-ness" is reinforced. For young people, migrants, or those experiencing social exclusion, the choir can offer a safe space that strengthens their expressive capacity. Helen Phelan's long-term ethnographic research with migrant choirs in Ireland vividly demonstrates how ritual singing plays a vital role in processes of social integration, emotional expression, and spatial belonging. According to Phelan (2018), through "borrowed rituals," individuals both experience and shape collective identity in public spaces.

Phelan's five dimensions of ritual resonance, embodied experience, performative structure, temporality, and implicit communication illustrate the multilayered role of the choir in identity formation. In this context, choirs are not only artistic collectives but also spaces of cultural memory where identities are continuously reconstructed (Phelan, 2018).

Various studies have shown that individuals who participate in choirs begin to perceive themselves not just as singers, but as integral members of a group. This sense of belonging strengthens identity on both personal and societal levels. The transformation experienced within the choral space fosters self-understanding and meaningful relationality through artistic expression. As such, the choir is not merely a space where identity is represented it is also a site where identity is actively produced.

The Historical Background of Choral Culture

Throughout history, choral music has played multiple roles as an aesthetic and ideological tool in shaping modern societies. Particularly from the 19th century onward, with the rise of nationalism across many European countries, choirs became not only musical ensembles but also spaces for producing cultural, social, and political identities.

Williams (2015) offers a detailed analysis of how working-class male choirs in Wales appropriated the oratorio tradition to construct both class-based and national identities. These choirs functioned not merely as musical groups but as collective identity spaces rooted in solidarity and a shared ethic of labor. Events such as the Eisteddfod choral competitions reinforced both social mobilization and cultural memory, becoming symbolic carriers of Welsh identity.



Similarly, Leterrier (2015) and Marković (2015) illustrate the role of choral societies in the construction of national identity in France and Serbia. During the French Third Republic, school and civic choirs were deployed as ideological tools to disseminate secular and nationalist values. In Serbia, choirs symbolized both cultural resistance in the post-Ottoman era and aspirations for European integration. These examples demonstrate that choirs have not only preserved traditions from the past but have also embodied modernist visions of the future.

Vidaud (2015) and Lajosi (2015) emphasize how choral movements in Central and Baltic Europe became entangled with ideals of populism, folklore, and cultural authenticity, contributing to the re-articulation of ethnic identities. In countries like Estonia, Latvia, and Lithuania, song festivals were seen as forms of “silent revolutions” enacted through music and became peaceful acts of resistance against totalitarian regimes. Estonia’s “Singing Revolution” (1987–1991) remains a striking example of how mass choral performance enabled political subjectification. Here, music served not just as a means of expression but as a direct instrument of social transformation.

Religious choral practices have also historically functioned as powerful tools for transmitting collective identity and shared values. Church choirs, particularly in Western Europe, extended beyond liturgical duties to become vehicles for both educational and social norms. From the German *Kantorei* tradition to Anglican cathedral choirs in England, sacred music shaped choral culture by linking spiritual formation with the harmonization of collective voices. These practices contributed to both vertical and horizontal forms of belonging within religious communities and laid the foundation for early Western music pedagogy.

In the Nordic countries, choral culture developed not only as a means of national identity formation but also as part of a broader ideology of social equality and welfare. In nations such as Sweden and Norway, choral practice evolved into a socially engaged practice that prioritized participation, emotional well-being, and collective responsibility over individual excellence. The choral movement led by Eric Ericson in Sweden offered a modern choral aesthetic that fused technical excellence with democratic engagement. This model promoted a conception of choral leadership that emphasized facilitation over authoritarian control, and encouraged singers to contribute not only vocally but also to decision-making processes.

In the Turkish context, choral initiatives during the early Republican period especially those carried out through *Halkevleri* (People’s Houses) and *Village Institutes* exemplify efforts to cultivate civic consciousness through aesthetic means. These practices, which blended Western polyphony with local musical elements, should be understood not only as artistic endeavors but as part of a broader pedagogical and ideological reform agenda. Today, choirs operating within civil



society organizations and universities continue to reflect this historical continuity in contemporary forms.

Historical examples clearly demonstrate that choral music has served both as a collective mode of voicing and as a medium of social organization. Cultural identity, political discourse, social solidarity, and individual self-construction are all interwoven within the fabric of choral practice. Thus, in historical context, the choir should be understood not only as an artistic practice but also as a formative agent in shaping the public sphere.

Fields of Practice and Educational Dimensions

Choral music is not merely an aesthetic activity; it is a multilayered field of practice with pedagogical, social, and psychological dimensions. Beyond these effects, the choir also serves as a microcosm of democratic life. In educational settings, choral participation supports not only cognitive and emotional development, but also cultivates democratic skills such as collective decision-making, shared responsibility, and the internalization of participatory culture.

Choir practice fosters abilities closely associated with democratic life, including self-discipline, empathy, attentive listening, and collaborative decision-making. In this regard, choral engagement is not only a musical pursuit but also a powerful tool for ethical and civic education. As Paul Woodford (2005) emphasizes, music education can foster democratic consciousness when grounded in a critical pedagogical framework, and the choir provides a unique environment for this purpose.

Choral education supports social-emotional development by promoting not just vocal training but also a sense of belonging, self-confidence, and mutual responsibility (Harley, 2017). This approach reveals that choir pedagogy responds not only to technical skills but also to individuals' psychosocial needs through a holistic educational model. Studies have shown that choral participation among adolescents positively influences identity development and group social cohesion (Garnett, 2017).

One of the foundational principles of democratic societies inclusion finds concrete expression in choir settings. Choirs that bring together individuals of different ages, abilities, and socioeconomic backgrounds create an environment that supports equality and diversity in education. Especially in choirs involving individuals with special needs, participation enhances emotional integration and social inclusion, offering an experience that transcends barriers through the universal communicative potential of music.



This potential is not confined to formal education. Amateur choir initiatives carried out by municipalities, cultural centers, NGOs, and voluntary organizations also play a vital role in fostering social inclusion. Such choirs become spaces where individuals reconnect with communal life and counteract contemporary challenges such as loneliness and alienation. Therefore, choir singing is not only a musical experience but also a practice of civic engagement and a cultural foundation for democratic life.

A choir is not only the convergence of voices, but also a space where silence and listening are experienced as a collective ethic. In this context, the choir enacts what Jacques Rancière defines as a ‘distribution of the sensible,’ a regime in which the visibility and audibility of bodies are politically mediated. An aesthetic-political space where decisions are made about whose voice is heard, what is felt, and which bodies are made visible (Rancière, 2004).

In conclusion, choral music is not merely a method of music education; it is a participatory, empathetic, and transformative learning environment that supports both personal and collective development. In this light, choral practice aligns directly with the democratic educational goals of the 21st century and should be understood as a holistic approach.

Conclusion

This study has demonstrated that choral music is not only an aesthetic art form but also an ethical and pedagogical space in which democratic life is experienced. As the social fabric of the 21st century continues to be reshaped by intensified individualism, emotional fragmentation, and growing inequality, it becomes increasingly necessary to reconstruct democratic values not only at the level of political systems but also within the micro-realities of everyday life. In this context, the choir should be regarded not merely as a convergence of voices, but as a living embodiment of democratic values in which principles such as equality, reciprocity, and participation are internalized.

In the choir, every voice is heard but no voice dominates or is silenced. This polyphonic structure aesthetically reflects the pluralism that modern democracies require. Moreover, establishing collective harmony necessitates that individuals cultivate values such as self-regulation, attentiveness, and responsibility. Thus, choir practice contributes to participatory democracy not only symbolically but also experientially. Woodford’s concept of “micro-democracy” underscores how the choir becomes a pedagogical space where individuals can develop civic virtues (Jordan & Bland, 2024, Freer, 2011). Here, music is not a technical performance but an ethical experience that fosters social awareness.



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The choir also serves as a platform for the reproduction of cultural belonging and social inclusion. As Phelan has shown, ritualized singing within choirs enables migrant individuals to reconfigure their identities in a collective context. Meanwhile, Thomas Turino's concept of "cultural cohorts" demonstrates how individuals who share similar values can generate alternative public spheres through musical practices. These spheres contribute to building the affective and experiential dimensions of democratic culture beyond its institutional frameworks.

In sum, choral music can play not only a metaphorical but also a practical and pedagogical role in the reconstruction of democratic societies. The egalitarian organization of vocal relationships, practices of harmony based on reciprocity, and the ethical dimension of collective creation position the choir as not only an art form, but also a stage for human rights, social equity, and participatory citizenship in the 21st century.

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