Innovative Development of Mathematics Beauty and Aesthetic Education

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Abstract. This paper seeks to discuss three issues: first, analyze the connotation of mathematical beauty to establish a multidimensional angle of mathematical aesthetics; Second, form the concept of "integration of disciplines" with an awareness of comparing mathematical beauty with other disciplinary beauty; Third, analyze the educational ideas of different schools, and integrate the mathematical beauty into teaching practice.

Keywords: Mathematical beauty · Aesthetic education · Teaching model

1 Introduction

Mathematical beauty is an important component of mathematics. Xu Lizhi (1997) explained that the beauty standard in mathematics is consistent with that of general beauties, which can be attributed to simplicity, unity, harmony, symmetry, novelty, and etc. [1] Li Zhengyin (2003) summarized the mathematical aesthetic ability into three levels, and embodied it in learning and evaluation, that is, feeling beauty, appreciating beauty and creating beauty. [2].

The above analysis shows that in the concept of mathematical beauty, mathematics and aesthetics are not simple addition, but clever integration. This paper seeks to discuss three issues: first, analyze the connotation of mathematical beauty to establish a multi-dimensional angle of mathematical aesthetics; Second, form the concept of "integration of disciplines" with an awareness of comparing mathematical beauty with other disciplinary beauty; Third, analyze the educational ideas of different schools, and integrate the mathematical beauty into teaching practice. The first and second aspects respectively focus on the breadth and depth of cognition, while the third one means the methodology to cultivate the aesthetic ability in mathematics learning and to analyze the educational function of mathematical beauty with Xu's five orientations and Li's three levels. These three levels need to be explored in the teaching practice of higher mathematics, and they are the key to effectively realize the educational function of mathematical beauty. Mathematics is a system of abstract symbols and logical reasoning, and the beauty of mathematics is the indirect embodiment of both elements. Xu Lizhi is the founder of the theoretical system of mathematical beauty among Chinese mathematics educators, and

he fully recognized the fundamental role of mathematical beauty played in understanding truth. [3].

In recent years, scholars have already discussed the basic issues on the essence of mathematical beauty, based on the full research on the nature and philosophical thinking of mathematical beauty, but lack of attention to the innovation of realizing the function of higher mathematics education.

Therefore, this paper selects the Tongji Edition of Higher Mathematics in 2014, and integrates the concept of mathematical beauty to analyze the relationships between the chapters of series and limits. This paper discusses knowledge points step by step based on Li's three levels, and aims to open up new ideas for solving practical mathematical problems, establishes a multi-dimensional cognitive perspective of higher mathematics, provides an innovative framework for the establishment of knowledge system, and offers new ideas for the practical cultivation of discipline literacy.

2 Similarities and Differences Between Mathematical Beauty and Other Beauty

2.1 Process and Method of Comparative Study

Chinese educator Cai Yuanpei [4] summarized the role of aesthetic education as, "All the courses in schools are closely related to aesthetic education." In this paper, according to the Catalogue of Academic Degrees and Personnel Training Disciplines (2011) [5] promulgated and revised by the Academic Degrees Committee of the State Council and the Ministry of Education of China, excluding the science category to which mathematics belongs, a total of 12 discipline categories are used as the reference, and the key words of "discipline category" and "beauty" are used to search in the full-text database of Chinese academic journals, and the documents that meet the requirements are screened based on the download quantity from high to low to locate the most representative theoretical research and practical research of each discipline category. In this paper, 24 reference papers were targeted and another 24 papers about mathematical beauty were selected as comparative research, therefore a total of 48 research samples were included. This paper is divided into two modules of theoretical research and practical research and five specific fields based on the analysis of the research direction of literature. Theoretical research can be mainly divided into "essence and characteristics", "theoretical construction" and "interdisciplinary research" these three categories, while the practical research is categorized into "aesthetic ability cultivation" and "subject aesthetic education". Some documents and data will involve different fields, for example, some papers will elaborate the essence and characteristics in depth while constructing the theory, therefore the definition of the research direction of the documents based on specific contents is necessarily analyzed in this paper. On all these counts, this paper aims to explore the similarities and differences between mathematical beauty and other beauty from five fields by means of comparison and qualitative analysis.

2.2 Five Fields of Aesthetics in Mathematics and Other Disciplines

Papers in the category of essence and characteristics revolve around questions such as "what is the beauty of a discipline" and "what are the essence and characteristics of the

beauty of a discipline", elaborating on the connotation, characteristics, basic system and research value of the beauty of a discipline, or discussing specific definitions of the nature based on reality, for instance, analyzing the concept and essence of evaluation view and appreciation view. In terms of philosophical beauty, Xie Weiying [6] put forward the proposition that the beauty of art is in the context, the beauty of science is in logic, and the beauty of philosophy is in thought, and the connotation of philosophical beauty is defined through a system in which philosophy is defined by the beauty of the vast realm, of deep discernment, and of elegant abstraction to the beauty of transcendent humanity. In the field of mathematical beauty, Xu's [1] notion of scientific culture of man and aesthetic consciousness is the progenitor.

The most common research idea in the field of disciplinary beauty is focused on the theoretical construction, and on the papers of the proposer of this disciplinary aesthetics to lead in new views and ideas. Scholars for the nature of disciplinar9beauty have studied around the existing literature for horizontal comparison or from the vertical, presenting the value of disciplinary beauty at different theoretical levels, and emphasizing on the form, ideas, and conclusions of the research in general. Wu Diaogong [7], a theoretical constructor in the field of literary beauty, argues that the aesthetic principle of literary beauty is enlightening to create a bridge of empathy between readers and authors, and can be viewed as a rhyme and mood after the realistic beautification of literary works.

A hot topic in the study of academic beauty is interdisciplinary research, which focuses on combining basic philosophical ideas with basic literary concepts. Scientific and effective interdisciplinary research can provide concrete solutions and pave the way for subsequent research. Mr Xu Lizhi [8], who has published on mathematical aesthetics and literature, cites the example of the great Chinese poet Li Bai's poem "the solitary sail is far away from the blue sky, but only the Yangtze River flows across the sky" in which the idea of mathematical limits is implied, as the shadow of a sailing ship tends to zero with time. Xu Lizhi's concept of interdisciplinary studies in literature has served as an accepted guideline for the reform of the higher education sector in the cultivation of talents with a mix of arts and science. In his discussion of educational beauty, Zhong Yijun [9] mentions that the educational process is the unity of truth and goodness, of conformity and purposefulness, and that educational activities need to conform to the laws of beauty.

One of the competencies that teachers need to develop implicitly in their teaching activities is aesthetic competence, and it needs to start with the accumulation of specific knowledge. As most aesthetic competence development suffers from aesthetic misconceptions, a comparative analysis of the literature in this paper reveals that promoting aesthetic competence development is both general in nature and specific in its narrative. The following five strategies can be used to implement the development of aesthetic competence: (1) Teaching specific knowledge points as a basis for setting up appreciation sessions; (2) Setting the context for teaching by making appropriate use of existing resources and relevant examples from textbooks. (3) Applying specific guiding questions in teaching to drive student development. (4) Guiding students to self-inquiry in the form of practical, tabletop research to try to understand aesthetics. (5) Promoting aesthetic competence through communication or exploration.

Zhang Dianyu [10] was the first to propose the theoretical idea of applying disciplinary aesthetic education to classroom teaching, defining four levels of aesthetic education: (1) Beauty. Formal symmetry, harmony and simplicity will convey the sense of beauty, but formal beauty can not necessarily equal to true beauty. (2) Aesthetic. The form of mathematical formulas is often closely linked to aesthetics, but beauty should not be avoided by a one-sided view of unaesthetic form. (3) Wonder. A wonderful interest in mathematics is developed as a matter of course through cultivation. (4) Perfection. Perfection is the highest level of mathematical beauty. Zhang Qingxu [11] studied legal aesthetics, claiming that aesthetics is conducive to promoting the development of the discipline and to cultivating human sentiment, stimulating the internalization of human psychological structure, transforming morality and knowledge into a spiritual quality in human beings, and improving the thinking and application skills of learners and enhancing their learning realm.

2.3   Research Conclusion

Aesthetic research in different disciplines has gone through several stages, i.e. from the formulation of basic aesthetic concepts in the discipline, to the continuous enrichment of the conceptual system of beauty in the discipline, and then to the multi-dimensional expansion of teaching or practice. The continuous in-depth theoretical research drives innovation in classroom practice, which in turn contributes to the increasing improvement of the theoretical system by way of feedback. The disciplinary field develops from theory to practice, and the combination of different disciplines and aesthetics produces differences due to different orientations, concepts and ideas, and the underlying reason is that the disciplinary field is subject to different perceptions and definitions.

3   Conclusion

This study integrates the various schools of thought on "mathematical beauty" and finds that most of the papers are qualitative studies, lacking empirical investigations in the classroom. Besides, few in-depth comparative study is conducted, but many are staying in simple statements, pointing to "the development of aesthetics in different disciplines has similarities" without further analysis. Therefore, this study uses a classification method to divide existing theoretical studies into "essence and characteristics," "theoretical constructs," and "interdisciplinary studies," and to divide previous practical studies into "aesthetic ability development. The aim is to make scholars pay attention to the improvement of students' aesthetic ability and to apply the existing mathematical beauty theory in practice.

The methodology of integrating mathematical aesthetics into teaching practice is the future direction of research, which requires researchers to focus both on students' aesthetic experience, and ways to enhance their potential aesthetic abilities and deepen their understanding of the subject. Mathematical beauty arises from aesthetic cultivation, and it has now been recognized that the ultimate level of disciplinary aesthetic competence lies in the cultivation of students' ability to create beauty, i.e., to have a deep understanding of the discipline they are studying. Therefore, students' disciplinary aesthetic

literacy should receive more attention in the later stages of cultivation, for example, by asking students multi-level mathematical aesthetic appreciation questions, rather than staying at one-way teacher indoctrination, allows students to enhance the competence to create beauty. This places high demands on teachers, who should have a systematic and structured internalization of mathematical beauty for students to develop in three dimensions in terms of core literacy enhancement, and therefore more relevant research should be conducted focusing on teachers' teaching tasks and providing directions for inquiry question design.

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