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A Book Review of Students' Collaborative Problem Solving in Mathematics Classrooms: An Empirical Study

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ABSTRACT

This article reviews *Students' Collaborative Problem Solving in Mathematics Classrooms: An Empirical Study*, edited by Yiming Cao and published by Springer Singapore in 2024 in the *Perspectives on Rethinking and Reforming Education* series. The book examines collaborative problem solving in mathematics classrooms, focusing on social interaction, mathematical communication, co-construction of knowledge, and teacher facilitation. Although this topic has been widely discussed in mathematics education, further analysis is needed on how task design, classroom interaction, and teacher intervention support collaborative mathematical problem solving. This review aims to examine the book's contribution to mathematics education and collaboration-based learning. Using a descriptive-critical method, it analyzes the book's structure, theoretical foundations, learning activity design, empirical orientation, strengths, limitations, and implications. The review indicates that the book contributes to understanding mathematics learning as a socio-cognitive process in which students negotiate meaning, present arguments, and construct solutions collaboratively. It also highlights teachers' roles in designing, guiding, and intervening in collaborative activities. However, its focus on Chinese mathematics classrooms may limit transferability to broader educational contexts, and its operational guidelines remain limited. Overall, the book is a valuable reference for educators, researchers, and practitioners and suggests future research on task design, teacher intervention, and collaborative problem-solving assessment.

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1. INTRODUCTION

Collaborative problem solving has become an essential competency in 21st-century mathematics learning. Mathematics learning is no longer viewed merely as a process of obtaining correct answers, but also as an opportunity for students to communicate mathematically, express reasoning, engage in argumentation, negotiate meaning, and

construct shared understanding through interaction with their peers [1]–[6]. In this context, collaborative problem solving is highly relevant because it integrates cognitive and social processes that support deeper mathematical understanding [7]–[14].

Previous studies have shown that collaborative problem solving can support students' mathematical communication, reasoning, participation, and problem-solving abilities [15]–[18]. However, effective collaboration does not occur automatically in classroom practice. Students may experience difficulties in developing productive communication, distributing roles, presenting ideas coherently, responding to peers' arguments, and reaching shared problem-solving strategies [17], [18], [20]. In addition, teachers often face challenges in designing collaborative tasks, guiding group interaction, providing appropriate intervention, and assessing both individual and group contributions during collaborative activities [21]–[30].

The book Students' Collaborative Problem Solving in Mathematics Classrooms: An Empirical Study, edited by Yiming Cao, offers an important and timely contribution to this discussion [19]. Published by Springer Singapore in 2024 as part of the Perspectives on Rethinking and Reforming Education series, the book provides an empirical and theoretical examination of collaborative problem solving in mathematics classrooms. Its significance lies in its focus not only on students' learning outcomes, but also on the processes of social interaction, mathematical communication, co-construction of knowledge, and teacher facilitation. This makes the book relevant for current mathematics education discourse, particularly in relation to collaboration-based learning and 21st-century competencies.

Despite the growing number of studies on collaborative problem solving, there remains a need for critical reviews that examine how this topic is presented in recent scholarly books, especially those that connect empirical classroom evidence, task design, student interaction, and teacher intervention. Therefore, the gap addressed in this review lies in the limited critical analysis of book-length empirical works that discuss collaborative problem solving in mathematics classrooms, particularly from the perspectives of classroom interaction and teacher facilitation.

This article aims to critically review Students' Collaborative Problem Solving in Mathematics Classrooms: An Empirical Study by examining its main ideas, theoretical foundations, empirical orientation, strengths, limitations, and implications for mathematics education. This review contributes to the literature by providing a structured evaluation of the book and identifying its relevance for educators, researchers, and mathematics education practitioners who seek to develop collaborative problem-solving practices in classroom learning.

2. METHOD

This study employed a descriptive-critical book review method to analyze *Students' Collaborative Problem Solving in Mathematics Classrooms: An Empirical Study*, edited by Yiming Cao and published by Springer Nature Singapore in 2024. This method was considered appropriate because the study did not involve primary data collection, but

focused on examining, interpreting, and critically evaluating the content of the reviewed book.

The primary data source of this review was the book itself, while secondary data were obtained from relevant literature on collaborative problem solving, mathematics education, classroom interaction, mathematical communication, task design, and teacher intervention. The supporting references were selected based on topic relevance, theoretical significance, and their direct relationship to the main issues discussed in the book. Priority was given to literature that specifically addressed collaborative learning and problem solving in mathematics classrooms. To ensure a systematic review process, a review matrix was developed based on structured book review criteria [31]–[32]. The criteria used in this review are presented in Table 1.

Table 1. Review Criteria

No.	Review Criteria	Focus of Analysis
1	Book structure	Chapter organization, coherence of ideas, and clarity of discussion
2	Theoretical foundation	Concepts, theories, and perspectives used to explain collaborative problem solving
3	Empirical evidence	Classroom-based evidence, research findings, and data presented in the book
4	Classroom relevance	Relevance of the book to mathematics learning practices
5	Pedagogical implications	Implications for task design, teacher facilitation, and classroom interaction
6	Limitations	Contextual, conceptual, and practical limitations of the book
7	Contribution to mathematics education	The book's contribution to research, theory, and practice in mathematics education

The review was conducted through several analytical stages. First, the book was read comprehensively to understand its overall structure, main themes, and central arguments. Second, important notes were taken regarding the book's key ideas, theoretical perspectives, empirical findings, and pedagogical implications. Third, these notes were categorized based on the review criteria. Fourth, the ideas presented in the book were compared with relevant supporting literature to identify their consistency, relevance, and contribution to mathematics education. Fifth, a critical evaluation was carried out by examining the strengths, limitations, and transferability of the book's ideas to broader educational contexts. Finally, the results of the analysis were synthesized into several discussion themes, including the summary of the book content, the role of mathematics and mathematics educators, theoretical foundations, learning activity design, empirical research, critical analysis, and implications for mathematics education [33].

This analytical procedure was applied to ensure that the review was not merely descriptive, but also critical, transparent, and evidence-based. Therefore, the evaluation of the book was conducted using clear criteria and supported by relevant literature.

3. RESULTS AND DISCUSSION

This section presents the results of the descriptive-critical review of Students' Collaborative Problem Solving in Mathematics Classrooms: An Empirical Study. The discussion is organized based on the review criteria, including the structure of the book,

theoretical foundation, empirical evidence, classroom relevance, pedagogical implications, limitations, and contribution to mathematics education.

Structure and Main Content of the Book

The book consists of eleven substantive chapters that discuss collaborative problem solving in mathematics classrooms from different but interconnected perspectives. These chapters address collaborative knowledge building, group participation, authority relations, opportunity to learn, mathematical communication, conflict discourse, peer interaction, teacher noticing, teacher intervention, and assessment of collaborative problem solving. Table 2 summarizes the structure and main focus of the book.

Table 2. Summary of the Book Chapters

Chapter	Main Topic	Key Argument	Empirical Evidence	Reviewer's Critical Note
1	Collaborative problem-solving teaching in a secondary school mathematics classroom	Collaborative problem solving requires the integration of cognitive processes and social interaction in mathematics learning.	Classroom-based discussion of collaborative problem-solving teaching in secondary mathematics.	Provides a strong introductory foundation, but practical classroom procedures need clearer elaboration.
2	Collaborative knowledge building in high- and low-performance groups	The quality of group interaction influences how students build mathematical knowledge collaboratively.	Comparison of high- and low-performance groups in mathematical problem solving.	Useful for understanding group dynamics, although broader classroom contexts could be discussed further.
3	Students' participation in collaborative task solving	Students' participation patterns affect the success of collaborative mathematical problem solving.	Analysis of Chinese students' participation in group-based mathematical tasks.	Highlights the importance of participation, but transferability to different learning cultures needs consideration.
4	Individual authority and group authority relations	Authority relations shape how students contribute ideas, negotiate meaning, and make decisions in groups.	Classroom interaction analysis of authority relations in collaborative problem solving.	Offers an important perspective on power relations and participation in group learning.
5	Opportunity to learn in collaborative problem solving	Students' opportunities to learn are influenced by task design, peer interaction, and teacher support.	Evidence from Chinese secondary mathematics classrooms.	Shows the connection between classroom structure and students' learning opportunities.
6	Mathematical communication in collaborative problem solving	Mathematical communication supports students in explaining ideas, negotiating meaning, and constructing shared understanding.	Analysis of secondary school students' mathematical communication.	Provides a strong contribution to communication-based mathematics learning.
7	Conflict discourse in collaborative	Conflict can support learning when it leads to	Analysis of conflict discourse during	Offers valuable insight into how disagreement

Chapter	Main Topic	Key Argument	Empirical Evidence	Reviewer's Critical Note
	problem solving	productive argumentation and negotiation of mathematical meaning.	mathematical collaborative problem solving.	can become a productive learning resource.
8	Peer interaction in collaborative problem solving	Peer interaction influences students' reasoning, participation, and collaborative solution strategies.	Analysis of student interaction in peer collaborative mathematical problem solving.	Relevant for teachers in designing and managing group-based mathematics learning.
9	Teacher noticing of collaborative problem-solving processes	Teachers' ability to notice students' collaborative processes affects how they understand and support student learning.	Comparison of experienced and preservice teachers' noticing of students' collaborative problem solving.	Important for teacher education and professional development.
10	Teacher intervention in collaborative mathematics problem solving	Teacher intervention can support students' collaboration when it is timely, focused, and pedagogically appropriate.	Analysis of teacher intervention in secondary school collaborative mathematics classrooms.	Strong practical relevance, but more operational guidance for teachers is needed.
11	Evaluation of students' collaborative problem solving	Assessment of collaborative problem solving should consider both the process and the product of students' work.	Evaluation framework for students' collaborative problem-solving activities.	Important for assessment development, but classroom-ready rubrics need further elaboration.

The table shows that the book is not merely a general discussion of collaborative learning. Rather, it presents a structured examination of how students interact, communicate, negotiate authority, construct knowledge, respond to conflict, and receive support from teachers during mathematical problem-solving activities. From the reviewer's perspective, the strongest feature of the book lies in its effort to make classroom interaction visible as an important component of mathematics learning.

Collaborative Problem Solving as a Socio-Cognitive Process

The book positions collaborative problem solving as a socio-cognitive process. This means that mathematical understanding is not only developed through individual thinking, but also through interaction, communication, negotiation, and shared construction of meaning. Students are expected to exchange ideas, justify strategies, respond to peers' arguments, and evaluate alternative solutions during collaborative mathematical tasks. This perspective is important because mathematics learning is often associated with individual achievement and procedural accuracy. The book expands this view by showing that mathematical learning also involves language use, argumentation, social participation, and collective reasoning. In this sense, collaborative problem solving is not simply a matter of placing students into groups. It requires purposeful task design, productive interaction, clear participation structures, and appropriate teacher support.

The review indicates that the book contributes to mathematics education by emphasizing the process through which students construct mathematical meaning together.

This is consistent with previous studies showing that students' mathematical reasoning and argumentation play an important role in solving mathematical tasks, especially when the tasks require justification, interpretation, and comparison of strategies [34].

Theoretical Foundation of the Book

The theoretical foundation of the book is rooted in the view that learning is a social and cognitive activity. Students construct knowledge not only through personal mental processes, but also through interaction with others. In collaborative mathematical problem solving, students ask questions, propose ideas, give explanations, challenge arguments, and refine strategies through discussion. The book uses this theoretical perspective to explain why classroom interaction should be treated as an important object of analysis. Through interaction analysis, teachers and researchers can identify students' participation patterns, the quality of mathematical communication, and the ways in which knowledge is co-constructed during group work.

From the reviewer's perspective, this theoretical orientation is one of the strengths of the book because it connects mathematics learning with social interaction and classroom discourse. However, the theoretical discussion would be more useful for classroom teachers if it were accompanied by clearer examples of how these theories can be translated into lesson planning, task design, and assessment practices.

Activity Design and Classroom Relevance

One of the important themes in the book is the role of activity design. The book emphasizes that collaborative problem solving will not occur effectively if mathematical tasks are not intentionally designed to encourage discussion, reasoning, and shared decision-making. Tasks that are too simple may not require meaningful collaboration, while tasks that are too complex without sufficient scaffolding may hinder students' participation. The book suggests that effective collaborative tasks should allow students to compare strategies, communicate mathematical ideas, justify reasoning, and construct solutions collectively. This view is relevant to previous research showing that well-designed mathematical problems can reveal students' strategies and support mathematical reasoning [35].

The classroom relevance of the book lies in its attention to authentic learning processes. It shows that the success of collaborative learning depends not only on the task itself, but also on how students interact and how teachers manage the learning environment. However, the book provides limited operational examples, such as detailed lesson plans, task models, classroom management strategies, and assessment rubrics. Therefore, teachers who wish to implement collaborative problem solving may still need additional practical guidance.

Empirical Evidence Presented in the Book

The empirical orientation of the book is one of its major strengths. The book presents classroom-based evidence on students' collaborative mathematical problem solving, including patterns of peer interaction, group discussion dynamics, mathematical

communication, conflict discourse, teacher noticing, teacher intervention, and evaluation of collaborative problem solving. The empirical data discussed in the book include classroom observations, interaction analysis, video-based analysis, comparison of group performance, analysis of teacher noticing, and case-based examination of teacher intervention. These forms of evidence help readers understand how collaborative problem solving actually occurs in mathematics classrooms.

The review indicates that the book is particularly valuable because it does not discuss collaboration only at a normative level. Instead, it provides empirical descriptions of how students participate in groups, how they negotiate mathematical meaning, how conflicts emerge during discussion, and how teachers intervene in students' collaborative work. Nevertheless, the empirical context is largely based on Chinese mathematics classrooms. This provides rich and focused evidence, but it also raises questions about how far the findings can be transferred to different educational contexts.

Critical Analysis of Strengths and Limitations

The main strength of *Students' Collaborative Problem Solving in Mathematics Classrooms: An Empirical Study* lies in its comprehensive and evidence-based discussion of collaborative problem solving in mathematics learning. The book connects theoretical foundations, empirical classroom evidence, student interaction, mathematical communication, task design, teacher noticing, teacher intervention, and assessment. This integrative approach makes the book a valuable reference for researchers and mathematics educators. Another strength is the book's focus on the social dimension of mathematics learning. It highlights that students' mathematical understanding can develop through communication, argumentation, negotiation, and shared knowledge construction. This view extends the traditional understanding of mathematics learning as an individual cognitive activity and supports the idea that classroom interaction is central to mathematical development.

However, several limitations should be considered. First, the empirical focus of the book is largely situated in Chinese mathematics classrooms. This context is valuable because it provides detailed classroom-based evidence, but it may limit the transferability of the book's findings to other educational systems. Differences in curriculum structure, classroom culture, student participation norms, teacher authority, and teacher-student relationships may influence how collaborative problem solving is implemented in different countries. For example, in some classrooms, students may not be accustomed to openly challenging peers' ideas or engaging in argumentative discussion. Therefore, the book's insights should be adapted carefully to local classroom cultures. Second, the book provides limited operational pedagogical guidance. Although it offers strong conceptual and empirical analysis, it does not fully provide practical tools that teachers can directly use, such as lesson plans, examples of collaborative mathematical tasks, group formation strategies, classroom management procedures, scaffolding guidelines, or detailed assessment rubrics. This limitation is important because classroom teachers need concrete guidance to translate the book's ideas into daily teaching practice.

Third, the book gives more attention to classroom interaction processes than to the long-term development of students' mathematical abilities. Interaction analysis is important for understanding how collaboration occurs, but further research is needed to examine how the quality of collaborative interaction influences students' problem-solving ability, mathematical reasoning, communication skills, and learning disposition over time. Fourth, the assessment of collaborative problem solving remains a complex issue. The book recognizes the importance of evaluating collaborative processes, but teachers may still face challenges in assessing individual and group contributions proportionally. Without clear assessment instruments, collaborative learning may be evaluated only through final answers or group products, while students' reasoning, participation, communication, and contribution during the process may be overlooked.

Contribution to Mathematics Education

The book contributes to mathematics education in several ways. For researchers, it provides empirical evidence and analytical categories for studying classroom interaction, collaborative knowledge construction, teacher intervention, and assessment in mathematics learning. For teacher educators, it offers useful material for preparing prospective teachers to notice and interpret students' collaborative problem-solving processes. For classroom teachers, the book provides insight into the importance of task design, mathematical communication, peer interaction, and teacher facilitation. For curriculum developers, it highlights the need to integrate collaborative problem solving as part of 21st-century mathematics learning competencies.

Compared with existing literature on collaborative problem solving, the book's contribution lies in its specific focus on mathematics classrooms and its detailed attention to social interaction during mathematical problem solving. While many studies discuss collaborative learning in general, this book provides a more focused analysis of how collaboration operates in mathematical contexts, particularly through communication, conflict, participation, teacher noticing, and intervention. Overall, the book is more than a reference on collaborative learning. It invites readers to rethink mathematics classrooms as spaces where students learn not only mathematical concepts, but also how to reason, communicate, listen, negotiate, and construct solutions together.

Implications for Mathematics Learning

The review of this book offers several implications for mathematics learning. First, teachers should provide students with more opportunities to solve mathematical problems collaboratively. Such opportunities can help students develop mathematical understanding, communication skills, reasoning ability, and cooperation. Second, mathematical tasks should be carefully designed to promote meaningful collaboration. The tasks should be challenging, open enough to allow multiple strategies, and suitable for discussion among students. Good task design can encourage students to explain their reasoning, compare approaches, and evaluate solutions collectively. Third, teacher intervention should be carefully managed. Teachers need to provide guidance and scaffolding when students face difficulties, but they should avoid dominating the discussion. Effective intervention should

help students clarify ideas, maintain focus, and improve the quality of interaction without taking over students' thinking processes.

Fourth, assessment in collaborative problem solving should include both process and product. Teachers need to assess not only final answers, but also students' participation, mathematical communication, reasoning, argumentation, and contribution to group problem solving. Therefore, future studies should develop practical assessment rubrics that can be used in classroom settings. In summary, the book provides important insights into collaborative problem solving in mathematics classrooms. Its strengths lie in its theoretical and empirical analysis of interaction, communication, teacher intervention, and assessment. However, its China-based empirical context and limited operational guidance indicate the need for further research and practical development in diverse educational contexts.

4. CONCLUSION

This review examined Students' Collaborative Problem Solving in Mathematics Classrooms: An Empirical Study by analyzing its main ideas, strengths, limitations, and implications for mathematics education. The review indicates that the book contributes to understanding mathematics learning as a socio-cognitive process in which students construct mathematical understanding through interaction, communication, argumentation, negotiation, and shared knowledge construction. It also emphasizes that collaborative problem solving requires meaningful task design, productive classroom discourse, flexible group roles, and appropriate teacher intervention.

The book is valuable for mathematics teachers, teacher educators, and researchers because it provides insights into collaborative tasks, teacher facilitation, mathematical communication, and assessment. However, its empirical focus on Chinese mathematics classrooms may limit the transferability of its findings to other educational contexts. In addition, the book provides limited operational guidance, such as lesson plans, task examples, classroom management strategies, and assessment rubrics. The implementation of collaborative problem solving may also face practical challenges, including limited instructional time, large class sizes, unequal student participation, and differences in teacher readiness. Future research should examine collaborative problem solving in more diverse contexts and develop practical models for task design, teacher intervention, classroom discourse, and assessment instruments that measure both students' collaborative processes and final solutions.

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