

THE EFFECT OF TEACHING A SECONDARY VOCATIONAL MATHEMATICS COURSE BASED ON CREATIVE PROBLEM-SOLVING PROCESS COMBINED WITH OPEN-ENDED QUESTIONS TO ENHANCE MATHEMATICAL REASONING ABILITY

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ABSTRACTS

The purposes of this research were to 1) compare mathematical reasoning ability before and after implementing secondary vocational mathematics course, 2) compare mathematical reasoning ability after implementing the secondary vocational mathematics course based on creative problem-solving process combined with open-ended questions with criterion set at 70%. The sample was 30 second year students (1classroom) of Zhoukou Polytechnic. They were derived by cluster random sampling. The research instruments were 1) the secondary vocational mathematics course based on creative problem-solving process combined with open-ended questions and its lesson plans, 2) a test paper for second year students' mathematical reasoning ability with a reliability of 0.88. The data were analyzed by using mean, standard deviation, t-test for dependent samples, t-test for one sample. The qualitative data was analyzed using content analysis.

The findings indicated that 1) the data from the test of students' Mathematical Reasoning Ability revealed that the mean scores of the post-test ($\bar{x}$ = 38.3, SD = 3.56) were higher than that of the pre-test ($\bar{x}$ = 25.17, SD = 1.64) at .001 level of statistical significance (t_{29} = 27.15, p < .01); 2) the mean scores reflecting students' Mathematical Reasoning Ability after completion of the course was ($\bar{x}$ = 38.3, SD = 3.56), which was higher than the criterion of 70% at .001 level of statistical significance (t_{29} = 5.07, p < .01), were found to be at a high level.

Keywords

Creative Problem-Solving Process, Open-ended Questions, Mathematical Reasoning Ability

Significance of the Problem**1. Context: National and Global Calls for Educational Transformation**

Since 2010, China has positioned educational reform as a national priority. The Outline of the National Medium- and Long-Term Education Reform and Development Plan (2010–2020) emphasized fostering student-centered learning, innovation capacity, problem-solving, and lifelong learning skills (State Council of China, 2010). The General High School Mathematics Curriculum Standards (2017 Edition) further highlighted core competencies, diversified evaluation, and reasoning-based learning (Ministry of Education of China, 2018).

Internationally, OECD's PISA studies consistently show that mathematical reasoning and problem-solving are foundational competencies for future work, digital society, and innovation-driven economies (OECD, 2021). These global benchmarks reinforce the urgency for countries, including China, to develop students' reasoning abilities, especially in vocational education.

2. Problem: Challenges in Secondary Vocational Mathematics Education

Mathematics performance among secondary vocational students in China remains critically low, with over 70% scoring below 60 on standardized assessments (Fang & Zhao, 2019) and competence levels reported to be 0.8–1.2 SD lower than those of general high school students. International findings echo this gap, as vocational-track students score 50–80 points lower in mathematical literacy worldwide (OECD, 2021). Despite ongoing reforms, vocational mathematics teaching continues to emphasize rote learning, traditional lecturing, and summative testing (Li & Chang, 2006; Liu, 1995; Black & Wiliam, 1998). Consequently, students often find mathematics abstract, irrelevant, and lacking opportunities for reasoning, inquiry, and meaningful application (Boaler, 2002).

3. Theoretical Foundations Supporting Reform

To address the above challenges, several influential educational theories offer strong justifications for redesigning vocational mathematics curricula:

Creative Problem-Solving Process (CPS): Provides structured steps for identifying problems, generating ideas, and selecting solutions (Puccio et al., 2007).

Open-Ended Questions: Encourage flexible thinking, reasoning, multiple-solution paths, and creativity (Pehkonen, 1997).

Multiple Intelligences Theory (Gardner, 1983; Armstrong, 2009): Highlights learner diversity and supports differentiated teaching.

Metacognitive Theory (Flavell, 1979; Schraw & Dennison, 1994): Enhances self-regulation and awareness of reasoning processes.

Sternberg's Theory of Successful Intelligence: Integrates analytical, creative, and practical reasoning essential for vocational contexts.

Together, these frameworks reinforce the need for innovative, student-centered mathematics curricula.

4. Impact: Why Reform Is Needed Now

Because vocational students typically enter careers requiring applied problem-solving—such as manufacturing, engineering, computer technology, and service industries—weak mathematical reasoning directly limits their employability and upward mobility.

Employers report that over 60% of vocational graduates struggle with quantitative and logical tasks (China Vocational Education Employability Survey, 2021).

PISA framework states that reasoning ability is essential for adapting to automation, digital environments, and future workplace demands (OECD, 2021).

Thus, enhancing mathematical reasoning is not only a curriculum requirement but also a socioeconomic necessity.

5. Research Rationale & Approach

In response to these challenges, this study develops a secondary vocational mathematics course based on the Creative Problem-Solving (CPS) process combined with Open-ended Questions.

By integrating CPS, open-ended questioning, metacognitive strategies, and competency-based teaching under a student-centered framework, this study supports both national reform goals and international competency standards.

Research Question

The research questions about the development of secondary vocational mathematics course based to creative problem-solving process combined with open-ended questions to enhance students' mathematical reasoning ability are as follows:

1. Are students' mathematical reasoning ability after implementing the developed secondary vocational mathematics course based to creative problem-solving process combined with open-ended questions higher than before?

2. Are students' mathematical reasoning ability after implementing the developed secondary vocational mathematics course based to creative problem-solving process combined with open-ended questions higher than 70%

Research Objectives

The objectives of this research were to determine the effectiveness of implementing the secondary vocational mathematics course based on creative problem-solving process combined with open-ended questions to enhance students' mathematical reasoning ability.

1. To compare mathematical reasoning ability before and after implementing secondary vocational mathematics course,
2. To compare mathematical reasoning ability after implementing the secondary vocational mathematics course based on creative problem-solving process combined with open-ended questions with criterion set at 70%

Research Methodology

Research Design

This study employed a quasi-experimental one-group pre-test-post-test design to examine the effectiveness of a newly developed “secondary vocational mathematics course based on the Creative Problem-Solving (CPS) process combined with Open-ended Questions”. The design allowed the researcher to measure changes in students’ mathematical reasoning ability and learning satisfaction before and after the intervention.

This approach is appropriate for authentic school settings where random assignment is not feasible, yet measurable instructional effects must be evaluated under real teaching conditions (Creswell, 2014).

Participants

Participants were secondary vocational students majoring in computer science from a vocational school in Henan Province, China. A total of 30 students enrolled in the mathematics course voluntarily participated in this study.

Instruments

Mathematical Reasoning Ability Test

Developed based on five components: logical thinking, problem-solving, abstract thinking, quantitative reasoning, and critical thinking.

Validated by expert review and pilot-tested for reliability.

Intervention Procedures

The research was conducted over 8 weeks, following these structured steps:

1. Pre-test Administration

Students completed the mathematical reasoning test before the intervention to establish baseline ability.

2. Implementation of the New Course

The course was delivered through eight lessons integrating:

Creative Problem-Solving steps (problem identification, idea generation, solution development, evaluation)

Open-ended questions requiring multiple reasoning paths

Student-centered activities such as group discussion, collaborative problem-solving, reflective tasks, and real-world contextualized problems

Teacher roles involved guiding inquiry, facilitating reasoning dialogue, providing scaffolding, and offering timely feedback.

3. Post-test

After the intervention, students took the same reasoning test.

Improvements were compared statistically.

Data Analysis

Quantitative data were analyzed using paired sample t-tests:

To determine whether students' mathematical reasoning ability significantly improved after the course, Statistical significance was set at $p < .01$.

Mathematical Reasoning Ability

Mathematical reasoning is the foundation of mathematical literacy, enabling students to analyze, justify, and apply concepts in diverse contexts (Kilpatrick et al., 2001). In this study, it is conceptualized through five key aspects:

1. Logical Thinking refers to the ability to reason systematically, construct valid arguments, and apply deductive structures (Hanna & de Villiers, 2012).

2. Problem-solving Skills refers to the competence to approach non-routine problems, plan strategies, and evaluate solutions effectively (Polya, 1945).

3. Abstract Thinking refers to the capacity to generalize from specific cases, manipulate symbols, and understand abstract structures (Sfard, 1991).

4. Quantitative Reasoning refers to the ability to interpret, model, and analyze numerical information for real-world applications (Steen, 2001).

5. Critical Thinking refers to the disposition to evaluate assumptions, analyze arguments, and justify claims with logical rigor (Facione, 1990).

These dimensions collectively provide the evaluative lens for assessing the effectiveness of Creative problem solving process with open-ended questions in improving vocational students' mathematical competencies.

Conceptual framework

In developing the secondary vocational mathematics course based on the Creative Problem-Solving (CPS) process combined with open-ended questions, the researcher reviewed major curriculum development theories as a theoretical foundation.

First, the Tyler Model (Tyler, 1949) provided one of the earliest systematic frameworks for curriculum design. Its brilliance lies in its simplicity and clarity, consisting of four essential steps that guide educators in identifying objectives, selecting learning experiences, organizing instruction, and evaluating outcomes.

Second, the Taba Model (Taba, 1962) emphasizes the enhancement of students' thinking skills and highlights the importance of teacher involvement in curriculum development. Her model involves seven steps, stressing the necessity of evaluating student achievement against established content standards to ensure alignment between teaching and learning outcomes.

Third, the Stake's Model (Stake, 1995) provides a holistic approach to educational evaluation. It emphasizes the importance of examining both the process and outcomes of educational interventions.

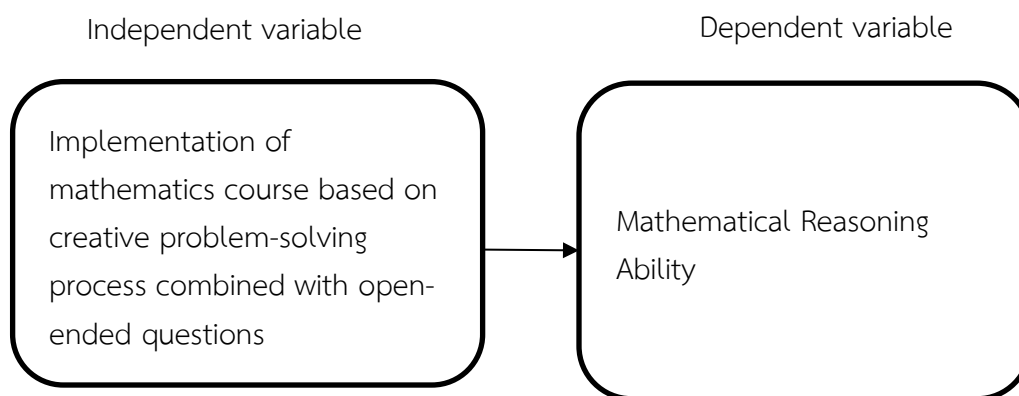


Figure 1 Independent variable and dependent variable

Population and Samples: The population of this study comprised 150 second-year students majoring in secondary vocational mathematics at Zhoukou Polytechnic. The population was divided into clusters based on academic classes, with

each class serving as a cluster containing approximately 30 students. Five clusters were randomly selected from the total pool, and all students within the chosen clusters were included in the sample. Then, a sample of 30 students was selected using cluster simple random sampling.

Research Instruments: Research instruments were essential tools for data collection. The instruments utilized in this study included:

Instruments for the experiment

1) Secondary vocational mathematics course based on creative problem solving process combined with open-ended questions

The researcher developed a draft course consisting of six components: 1) Principle of the curriculum, 2) Objective of the curriculum, 3) Curriculum content, 4) Teaching strategy, 5) Instructional material, and 6) Evaluation.

Five experts—two curriculum experts, two content instruction specialists, and one measurement and evaluation expert—evaluated the draft course using an 24-item evaluation form with 5-point rating scales. The mean score was 4.37 (SD = 0.56), indicating that the course was rated at a high level.

Table 1 The interpretation of appropriateness level

Mean scores	Interpretation
4.51 – 5.00	Very high level
3.51 – 4.50	High level
2.51 – 3.50	Moderate level
1.51 – 2.50	Low level
1.00 – 1.50	Very low level

Instruments for Data Collection

The data collection instruments included a pre-test, a post-test for assessing Mathematical Reasoning Ability.

Test Paper and Scoring Rubric for Students' Mathematical Reasoning Ability.

The examination paper consisted of 10 items (Two questions for each ability) designed to assess five core components of Mathematical Reasoning Ability—Logical Thinking, Problem-Solving Skills, Abstract Thinking, Quantitative Reasoning, and Critical Thinking. To ensure the instrument's quality and empirical robustness, multiple validation procedures were conducted prior to the main study.

Source and Calculation of Test Quality Metrics

The item difficulty (p-value) and discrimination indices (r-value) were derived from actual student responses collected during a pilot test rather than estimated solely through expert judgement. The pilot test involved 32 secondary vocational students with similar demographic and academic characteristics to the target sample, allowing the statistical indicators to reflect authentic learning performance. Classical Test Theory (CTT) procedures were used to calculate item difficulty (proportion of correct responses) and discrimination (item-total correlation). Results indicated that the test possessed suitable psychometric quality, with difficulty indices ranging from 0.41 to 0.59—considered moderate and desirable for differentiating student ability levels—and discrimination values above 0.20, meeting the recommended minimum threshold for educational assessments.

Tryout Procedures and Statistical Analysis

Before full implementation, the instrument underwent a structured tryout phase. Participants for the tryout were selected using convenience sampling, ensuring timely and accessible data collection while maintaining similarity to the actual study population. The purpose of the tryout was to evaluate item clarity, functionality, and statistical performance.

The following statistical techniques were applied:

Item-Objective Congruence (IOC) assessed by five experts yielded values from 0.60 to 1.00, confirming strong alignment with course objectives.

Item difficulty analysis identified whether items were too easy or too challenging, ensuring balanced coverage across reasoning dimensions.

Item discrimination analysis used Pearson's item-total correlation, confirming each item's ability to differentiate between high- and low-performing students.

Inter-rater reliability, assessed using the intraclass correlation coefficient (ICC) during the scoring trial, produced a value of 0.812, exceeding the acceptable threshold of 0.70 and indicating consistent scoring across evaluators.

Together, these metrics confirm that the test items possess adequate clarity, discrimination power, and alignment with the intended constructs.

Data collection

The data collection was implemented in the procedures as follows:

- 1) The sample was administered by a pre-test utilizing the constructed instrument to measure students' Mathematical Reasoning Ability.

2) Instruction was the development of the Secondary Vocational Mathematics Course based on Creative Problem Solving Process Combined with Open-ended Questions.

3) Following the implementation of the course, the sample completed a post-test with the same instrument that was utilized in the pre-test.

Data analysis

The collected data were analyzed by using statistical methods aligned with the research objectives:

1) The scores from the pre-test and post-test of the Secondary Vocational Mathematics Course based on Creative Problem Solving Process Combined with Open-ended Questions were compared by using a t-test for dependent samples.

2) The data of students' mathematical reasoning ability toward the course were analyzed to determine the different scores of mathematical reasoning ability with the criterion of 70% by using a t-test for one sample.

Research Results

The results were presented by the research objectives:

A comparison of students' Mathematical Reasoning Ability scores before and after participating in the Secondary Vocational Mathematics Course, which utilized Creative Problem Solving Process Combined with Open-ended Questions, was conducted using a paired-sample t-test.

Table 2 Comparison of students' Mathematical Reasoning Ability scores in the Secondary Vocational Mathematics Course before and after course implementation

Group	n	Pretest		Posttest		t	p
		$\bar{x}$	SD	$\bar{x}$	SD		
Experimental group	30	25.17	1.64	38.60	3.56	27.15*	p< .01

p< .01

As shown in table 2, the mean scores of mathematical reasoning ability for the pre-test was 25.17 with SD = 1.64, while the mean scores for the post-test was 38.60 with SD = 3.56. The analysis indicated that after the implementation of the secondary vocational mathematics course based on creative problem-solving process combined with open-ended questions, the post-test scores were higher than the pre-

test scores at the .01 level of statistical significance ($t_{29} = 27.15$, $p < .01$). These results demonstrate a notable increase in average scores following the course implementation.

The data presented in Table 2 demonstrate that students exhibited significant academic improvement in the secondary vocational mathematics course based on creative problem-solving process combined with open-ended questions. Furthermore, measurable enhancement was observed in students' mathematical reasoning ability. It emphasizes that the course did not only reinforce trigonometric concepts but also developed the five dimensions of reasoning ability;

Logical Thinking, Problem-solving Skills, Abstract Thinking, Quantitative Reasoning, and Critical Thinking.

A comparison of students' Mathematical Reasoning Ability scores after participating in the Secondary Vocational Mathematics Course implementation with the criterion of 70%, which utilized Creative Problem-Solving Process Combined with Open-ended Questions, was conducted using an one-sample t-test.

Table 3 The results of students' mathematics reasoning ability after learning through Secondary Vocational Mathematics Course based on Creative Problem-Solving Process Combined with Open-ended Questions with the criterion of 70 %

Components	N	Full score	Criteria score	$\bar{x}$	SD	t	p
1) Logical Thinking	30	10	7	7.73	0.65	4.25*	.001
2) Problem-Solving skills	30	10	7	7.80	0.54	5.76*	.001
3) Abstract Thinking	30	10	7	7.50	0.60	3.53*	.001
4) Quantitative reasoning	30	10	7	7.43	0.64	2.65*	.001
5) Critical Thinking	30	10	7	7.83	0.62	5.48*	.001
Overall	30	50	35	38.3	3.56	5.07*	.001

$p < .01$

As presented in Table 3, the mean scores of t students' mathematical reasoning ability test after learning through the secondary vocational mathematics course were 38.3 out of possible full marks of 50, and the standard deviation was 3.56, which was statistically higher than the determined criterion of 70% at the .01 level of statistical significance ($t_{29} = 5.07$, $p < .01$)

As indicated in Table 3, students reported high mathematical reasoning ability test levels with the course delivery format following their engagement with the Secondary Vocational Mathematics Course based on Creative Problem-Solving Process Combined with Open-Ended Questions.

Discussion

The results of the interviews with teachers and students, together with the review of relevant policy documents and prior research, revealed that the current secondary vocational mathematics course has persisting problems in six aspects: principles, objectives, content, teaching strategies, materials, and evaluation.

First, the principles of the course are still largely oriented toward examination results and knowledge transmission, rather than emphasizing students' reasoning skills and capacity for application. This aligns with findings from Zheng (2022), who argued that mathematics education in China often remains constrained by exam-driven orientations, creating a gap between students' learning outcomes and the intended competencies of reasoning and application.

Second, regarding course objectives, the current goals remain too general, emphasizing mastery of formulas and theorems but not explicitly targeting higher-order reasoning. As reported by Cai & Lester (2020), mathematics learning objectives must be clearly defined in terms of reasoning, abstraction, and problem-solving abilities if they are to effectively guide both teaching and assessment.

Third, the content of the curriculum is limited in scope and disconnected from students' vocational and real-life contexts. Such disconnections have been previously documented by Bao & Wang (2019), who noted that without real-world connections, vocational students often perceive mathematics as irrelevant and disengage from learning.

Fourth, the teaching strategies in current practice are predominantly teacher-centered, relying heavily on lecturing, explanation, and problem demonstration. This finding is consistent with Wu (2018), who described the "spoon-feeding" approach still prevalent in Chinese secondary vocational mathematics classrooms.

Fifth, concerning teaching materials and resources, teachers reported that textbooks and learning resources were outdated, lacking open-ended tasks, contextual problems, or opportunities for exploration. This finding echoes the critique by Guo (2021), who emphasized the need for enriched teaching media to stimulate reasoning and creativity.

Finally, in terms of evaluation, the current system relies excessively on summative assessments such as paper-and-pencil exams. This is consistent with findings from Li (2020), who noted that assessment reform lags behind curriculum reform, leading to a misalignment between objectives and evaluation practices.

In summary, the findings demonstrate that the current secondary vocational mathematics course faces systemic challenges across six dimensions. These shortcomings restrict the development of mathematical reasoning ability among students and justify the need for curriculum reform through new approaches such as CPS combined with open-ended questions.

The improvement of the mathematical reasoning ability result

After-class assessments revealed that students' mathematical reasoning ability scores improved significantly, with pre-test scores ($\bar{x} = 25.17$, $SD = 1.64$) and post-test scores ($\bar{x} = 38.60$, $SD = 3.56$). Statistical analysis confirmed this improvement ($t_{29} = 27.15$, $p < .01$), indicating that the Creative Problem-Solving Process Combined with Open-Ended Questions instructional approach effectively enhanced students' reasoning competencies. This course design cultivated reasoning across five dimensions: logical thinking, problem-solving skills, abstract thinking, quantitative reasoning, and critical thinking. The findings suggest that students were able to apply mathematical knowledge flexibly in new contexts, engage in deeper analysis of problems, and justify solutions with rigorous logical arguments.

A dual evaluation mechanism incorporating both item analysis (validity, reliability, difficulty, discrimination) and expert review ensured that the test results were valid and reliable. The Creative Problem-Solving Process Combined with Open-Ended Questions model proved particularly effective in improving higher-order reasoning skills by encouraging multiple solution paths, open-ended exploration, and reflective learning. This evidence-based approach not only validates the efficacy of the developed mathematics course but also provides a replicable framework for secondary vocational education, offering practical strategies for improving mathematical reasoning ability in applied learning environments.

Recommendations

Recommendations for Implication

1. Strengthening process evaluation and feedback

Due to the complexity of curriculum reform in secondary vocational mathematics and the time limitation of this research, the study is not perfect and requires further exploration. The implementation of the Creative Problem-Solving process combined with open-ended questions should not only focus on outcome evaluation but also emphasize ‘process evaluation’. Teachers should closely monitor students’ learning progress, promptly identify misconceptions, and provide targeted feedback. By encouraging students to engage in reflective learning during mathematical reasoning tasks, teachers can strengthen students’ ability to self-assess and refine problem-solving strategies.

2. Improving mathematical reasoning indicators

The determination of students’ mathematical reasoning ability in this study was based on expert consultation and the five identified components: logical thinking, problem-solving skills, abstract thinking, quantitative reasoning, and critical thinking. However, these indicators inevitably contain subjective elements due to experts’ personal orientations. Future research can further refine and localize the indicators to make them more adaptable to vocational contexts. In addition, involving experts from other regions and institutions could enhance the objectivity and reliability of the evaluation system.

3. Integration of educational technology into mathematics courses

Modern educational technology provides opportunities to improve students’ reasoning ability through dynamic visualization and interactive learning environments. Teachers of vocational mathematics should be trained to master technological tools such as GeoGebra, dynamic geometry software, and online collaborative platforms. Integrating these resources into CPS-based instruction can not only make abstract mathematical concepts more tangible but also enhance students’ engagement, efficiency, and reasoning ability. This digital integration supports the reform direction emphasized by the Ministry of Education of China and ensures that mathematics learning becomes both practical and innovative.

Recommendations for Further Research

1. Fostering reflective teaching and dual learning

Reflective teaching should be emphasized as both teachers and students engage in “dual learning.” Teachers refine their pedagogical practices by reflecting on students’ learning processes, while students develop metacognitive awareness by

learning ‘how to learn’. Future research could explore how CPS-based mathematics courses can systematically embed reflective teaching practices that promote self-regulation and higher-order reasoning skills.

2. Diversification of instructional methods

While CPS combined with open-ended questions has demonstrated significant effectiveness in enhancing reasoning, it should not be regarded as the sole approach. Mathematics educators should flexibly integrate other methods—such as problem-based learning, inquiry-based learning, or project-based approaches—to adapt to varying teaching contents and student needs. Future studies could compare different blended instructional models to determine their relative impact on reasoning and creativity.

3. Aligning vocational mathematics with core competencies

Mathematical reasoning ability is central to mathematical literacy and is reflected in the six competencies emphasized in international and national standards: mathematical abstraction, logical reasoning, data analysis, modeling, operations, and intuitive imagination. Future curriculum design should integrate these competencies within CPS-based mathematics teaching without isolating reasoning as a separate domain. Instead, reasoning should be cultivated naturally across diverse tasks and contexts, ensuring that vocational students acquire applicable and transferable skills for both professional practice and lifelong learning.

References

- Armstrong, T. (2009). *Multiple intelligences in the classroom* (3rd ed.). ASCD.
- Bao, J. & Wang, H. (2019). Challenges of mathematics learning in vocational education: Connecting theory and practice. *Journal of Mathematics Education Research*. 32(2), 45–58.
- Black, P. & Wiliam, D. (1998). Inside the black box: Raising standards through classroom assessment. *Phi Delta Kappan*. 80(2), 139–148.
- Boaler, J. (2002). Experiencing school mathematics: *Traditional and reform approaches to teaching and their impact on student learning*. Lawrence Erlbaum.
- China Vocational Education Employability Survey. (2021). *Annual report on employability of vocational graduates*. China Education Press.
- Cai, J. & Lester, F. (2020). Why is teaching with problem solving important to student learning? *Journal of Mathematical Behavior*. 60, 100828.
<https://doi.org/10.1016/j.jmathb.2020.100828>

- Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). SAGE Publications.
- Facione, P. A. (1990). *Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction*. American Philosophical Association.
- Fang, Y. & Zhao, H. (2019). A study on mathematics achievement among secondary vocational students in China. *Journal of Vocational Education Research*. 25(4), 56–63.
- Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive–developmental inquiry. *American Psychologist*. 34(10), 906–911.
<https://doi.org/10.1037/0003-066X.34.10.906>
- Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. Basic Books.
- Guo, L. (2021). Innovations in teaching resources for vocational mathematics education. *China Vocational Education Review*. 28(4), 77–85.
- Hanna, G. & de Villiers, M. (2012). Aspects of proof in mathematics education. In G. Hanna & M. de Villiers (Eds.), *Proof and proving in mathematics education* (pp. 1–10). Springer.
- Kilpatrick, J., Swafford, J. & Findell, B. (Eds.). (2001). *Adding it up: Helping children learn mathematics*. National Academy Press.
- Li, H. (2020). The reform of assessment practices in mathematics education. *Contemporary Educational Research*. 14(2), 123–134.
- Li, Q. & Chang, C. (2006). The role of mathematics education in cultivating logical and creative thinking. *Journal of Mathematics Education*. 15(2), 45–56.
- Liu, M. (1995). Problems and improvements in secondary vocational mathematics teaching. *China Vocational Education*. 12, 32–35.
- Ministry of Education of China. (2014). *Opinions on comprehensively deepening curriculum reform to implement the fundamental task of fostering virtue*. People’s Education Press.
- Ministry of Education of China. (2018). *General high school mathematics curriculum standards (2017 edition)*. People’s Education Press.
- OECD. (2021). *PISA 2021 mathematics framework*. OECD Publishing.
<https://doi.org/10.1787/19963777>
- Pehkonen, E. (1997). The state-of-art in mathematical creativity. *Zentralblatt für Didaktik der Mathematik*. 29(3), 63–67.
- Polya, G. (1945). *How to solve it*. Princeton University Press.

- Puccio, G. J., Mance, M. & Murdock, M. C. (2007). *Creative leadership: Skills that drive change*. Sage.
- Schraw, G. & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*. 19(4), 460–475.
<https://doi.org/10.1006/ceps.1994.1033>
- Sfard, A. (1991). On the dual nature of mathematical conceptions: Reflections on processes and objects. *Educational Studies in Mathematics*. 22(1), 1–36.
- Stake, R. E. (1995). *The art of case study research*. SAGE Publications.
- State Council of China. (2010). *Outline of the National Medium- and Long-Term Education Reform and Development Plan (2010–2020)*. People's Publishing House.
- Steen, L. A. (Ed.). (2001). *Mathematics and democracy: The case for quantitative literacy*. Mathematical Association of America.
- Taba, H. (1962). *Curriculum development: Theory and practice*. Harcourt Brace & World.
- Tyler, R. W. (1949). *Basic principles of curriculum and instruction*. University of Chicago Press.
- Wu, Y. (2018). Exam-oriented culture and mathematics teaching reform in china. *Chinese Education & Society*. 51(1), 62–74.
- Zhang, D. (1998). Mathematics education in the information age. *Mathematics Education Review*. 10(2), 15–21.
- Zhang, D. (1999). Innovation-oriented mathematics curriculum reform. *Journal of Curriculum Studies*. 7(3), 22–28.
- Zheng, T. (2022). Curriculum reform in mathematics: From exam orientation to reasoning cultivation. *Journal of Educational Change*. 30(1), 21–36.