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The Localized Practice and Application of Anchored Instruction in Primary School Mathematics Classrooms

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Abstract. To explore the practical application of anchored instruction in the Chinese educational context, this study carefully selected four classes (including two classes of Grade 1 and two classes of Grade 4) from a public primary school and three experienced frontline mathematics teachers in a first-tier coastal city of China as research participants, and systematically investigated the current situation and specific implementation details of the localized practice of this teaching model in primary school mathematics classrooms. The results demonstrated that anchored instruction has undergone certain adaptive transformation to adapt to the local teaching scenarios and students' learning characteristics. This adaptive transformation not only effectively alleviates teachers' daily teaching burden and reduces their work pressure, but also significantly improves students' classroom attention and participation, and further enhances the overall effectiveness and quality of classroom teaching. In future research, it is necessary to expand the sample size to include more primary schools in different regions and increase the number of research participants, and extend the research cycle to further verify the long-term effectiveness and wide applicability of anchored instruction in the Chinese educational context and provide more reliable and comprehensive research support.

Keywords: Anchored Instruction, Mathematics Education, Primary School Mathematics Classroom Practice

1. Introduction

It's possible to say that in China the primary mathematics education has changed paradigm of the sphere, passing to the innovative teaching through the prism of the policies of the recent curriculum reforms and the background of the development of the policy of the so-called Double Reduction. According to the Compulsory Education Mathematics Curriculum Standards (2022 Edition), mathematics should follow a student-centered approach and it should be based the development of core competencies. By reforming the teaching practice in mathematics, teachers are advised to engage learners with creative learning tasks and proper use of technology learning models in order to enhance students' mathematical thinking and literacy. This shift is local but it is aligned with the larger international trends in mathematics education. To take an example, the EU report Increasing achievement and motivation in mathematics and science learning in schools affirms that to make mathematics interesting to students and to make them realize that learning mathematics is practical,

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then the use of mathematics in several life situations should be part of the learning of primary schools. These tendencies promote a worldwide pedagogical shift in the direction of context-based mathematics education.

The primary school children are usually dependent on the concrete thinking and their cognitive process is at the concrete operational phase [1]. They cannot perform abstract reasoning formally and have limited capacity for abstract reasoning, comparison and synthesis [2]. Nonetheless, the abstractive feature of mathematics in mathematics learning as was done in geometry has emerged as a fundamental quandary to mathematics learning [3]. The classical teaching of mathematics where rote learning is used has apparent shortcomings in developing the mathematical reasoning and problem-solving skills in the students. Rote learning emphasizes the memorization of facts not understanding as opposed to being able to learn anything meaningfully or be able to transfer the learnt material to different contextual problems as Mayer argues [4]. Such constraints can impede the process of development of abstraction of students and can possibly affect the formation of the underlying sense of numbers in young learners [2].

2. Literature review

2.1. Theoretical framework: anchored instruction

Anchored instruction is a constructivist teaching model that is theoretically described, having three elements that inter-relate and that are situated context creation, autonomous inquiry, and collaborative learning.

The theory, proposed by Vanderbilt Cognitive and Technology Group [5], asserts that learning must be anchored in meaningful real-world problem situations, which are usually presented through videos and integrate data embedded in them and complex problems. These settings mobilize the background experiences of the students, and do not involve passive knowledge: students should derive information on their own, pinpoint sub-problems, and test their conjectures themselves [6]. To achieve inclusive learning environments, to further develop these factors, there is improved anchored instruction that plans heterogeneous group work and hierarchic inquiry activities to support diverse learners such as those possessing different mathematical problems [7]. Gao and Wang [8] also contextualized these theoretical components further in terms of Chinese education where situational creation must correspond to the content of the domestic textbooks and the everyday life experience of students, and collaborative learning must be mediated by adopting the traditional classroom teaching system. Not only does this preserve the central reasoning of the foreign theories [5] of situational embedding, active exploration and collaborative construction, but it provides greater practical applicability in the Chinese educational situations.

2.2. Review of current status: the application and existing challenges of anchored instruction in mathematics education

Application of anchored instruction in teaching mathematics has recorded tremendous positive impact.

First of all, Anchored instruction allows to acquire the knowledge and the skill of applying it: by relating the real-life scenarios to the teaching of mathematics, the students may be able to better grasp the mathematical knowledge [9].

Moreover, its teaching mode can be used in order to counteract math anxiety, as well as disrupted maladaptive learning cycles: this pedagogical mode allows students to acquire successful

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experiences in a particular situation of being able to solve problems repeatedly, assists students in accumulating mathematical confidence in small steps, and successfully breaks the vicious loop of anxiety scene to avoiding mathematics to bad grades to anxiety [10].

However, there are still several practical issues with anchored instruction in mathematics teaching that are incorporated into the Chinese education environment.

On one hand, traditional foreign anchored instruction is centered on macro real-world scenarios. However, the class hour arrangement for primary school mathematics in China is relatively tight. Constructing such scenarios not only requires teachers to invest a great deal of time and energy in curriculum design but also imposes high requirements on teachers' professional competencies such as scenario creation and interdisciplinary integration for the connection and implementation of macro scenarios. On the other hand, China's educational reform is undergoing continuous advancement at the current stage, with constant updates to curriculum standards and teaching concepts. Even newly developed anchored instruction projects need to promptly keep pace with the reform progress for iterative optimization, making it difficult to maintain timeliness in the long run. Moreover, frequent project upgrades and content revisions will bring additional pressure from human and financial input, further restricting its large-scale application.

What's more, the existing teaching evaluation system poses significant challenges for accurately evaluating its instructional effectiveness [11]. To elaborate, the existing evaluation system ignores anchored instruction's core dependence on specific scenarios, does not evaluate the comprehensiveness and rationality of scenario design, nor adjusts standards dynamically, and uses uniform standards even when imperfect scenarios lead to students' insufficient understanding of subject value, failing to reflect its real effect. Meanwhile, the effective evaluation of anchored instruction requires supporting resources, technical support and teachers' evaluation design capabilities, which the existing system lacks, failing to meet.

Under the interaction between the traditional evaluation system oriented toward short-term score improvement and the Chinese classroom model characterized by large knowledge volume and tight class schedules, the concept of constructing grand scenarios and guiding students' long-term exploration emphasized in anchored instruction is difficult to truly implement and normalize in the Chinese education system. Constrained by the above practical conditions, teachers are highly likely to design pseudo-scenarios with numerous irrelevant details in classroom teaching design, thereby deviating from the original intention of anchored instruction.

Under such conditions, a potential increase in students' cognitive load appears inevitable. In the designed teaching situations, if students cannot distinguish the details of core knowledge from irrelevant ones, they will spend a lot of cognitive resources dealing with irrelevant details [12], leading to the rise of extraneous cognitive load [13].What's more, students' attention will shift accordingly, and cognitive resources will be transferred from processing core knowledge to dealing with irrelevant details, thus forming a cognitive processing mode of "attending to trifles and neglecting the essentials" [14]. Lastly, the fourth challenge is the emergence of superficial pseudo-situations: if teachers only present real scenes superficially and fail to design complex problem chains suitable for students' cognitive level, they cannot guide students to carry out higher-order thinking and problem-solving activities [15].

Therefore, it is urgent to conduct empirical comparative studies in real classroom teaching environments in China to scientifically verify the actual effectiveness of anchored instruction. Meanwhile, based on national educational conditions, localized adjustments should be made to this teaching model to better adapt it to classroom practices in China.

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2.3. Research gap

At present, a wealth of literature has demonstrated the effectiveness of Anchored Instruction through experiments, but most of them are conducted based on the national conditions of European and American countries, and often rely on the design of long-term projects in "macro-situations". However, as indicated in Compulsory Education Curriculum Plan (2022 Edition) and 2022 National Statistical Bulletin on the Development of Education, such an anchored instruction originating from Europe and the United States is difficult to be fully implemented under the practical conditions of fixed class hours and large class sizes in China, which means its complexity and input costs are difficult to adapt to the practice of primary school mathematics classrooms in China.

Meanwhile, most relevant studies are theoretical discussions, focusing on middle schools or interdisciplinary fields. Few studies intuitively show the differences in classroom participation and knowledge comprehension through specific parallel class comparisons

3. Methodology

3.1. Research design

This research adopts a mixed-method approach to conduct a Comparative Case Study, combining qualitative data (from observations and interviews) and quantitative data derived from student questionnaires.

A questionnaire was developed based on the three-dimensional model of student engagement proposed by Fredricks [16] and the core components of anchored instruction outlined by Gao Wen [8], including situational creation, problem anchoring, independent inquiry, and collaborative learning. The instrument measures three dimensions: situational cognition, behavioral engagement, and emotional engagement.

In addition, semi-structured interviews were conducted with frontline primary school mathematics teachers to explore their perceptions and experiences of implementing anchored instruction. Classroom observations were also carried out to examine teachers' instructional practices and students' learning behaviors in authentic classroom settings.

3.2. Context and participants

The main respondents of the questionnaire survey are Grade 1 and Grade 4 students from a primary school in a first-tier city on the southeast coast of China, with two classes in each grade. The two classes in the same grade have the same class size and the overall level of students is similar. The independent-samples t-test results of the mathematics scores of the two Grade 4 classes and the two Grade 1 classes show no significant differences, proving that they all have baseline equivalence. Among them, Class 4 Grade 4 (39 students) and Class 2 Grade 1 (41 students) are the experimental groups (applying Anchored Instruction), and Class 3 Grade 4 (37 students) and Class 4 Grade 1 (41students) are the control groups (applying traditional teaching methods).The interviewees of the semi-structured interviews are front-line primary school mathematics teachers, which helps to further understand the mathematics education of teachers and students and make up for the deficiencies of the questionnaire.

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3.3. Data collection instruments

The instruments, including a Classroom Observation Rubric, a Questionnaire on Mathematics Learning of Primary School Students in a First-tier City and a semi-structured interview outline, were self-developed and validated by the researcher for the specific context of this study.

(1) Classroom Observation Rubric: This form records the number of students' hand-raising for classroom interaction, their concentration in discussions, as well as teachers' classroom organization instructional segments and visual pedagogical aids in class.

(2) Questionnaire: A 5-point Likert Scale is adopted, which includes 8 to 10 simple questions.

(3) Semi-structured interview outline: Semi-structured interview were conducted with three teachers after class, with each interview lasting 30-50 minutes.

3.4. Data analysis procedure

In this research, SPSS was used to conduct descriptive statistical analysis and independent samples t-tests on the questionnaire data, and manual thematic coding is carried out on the interview data to extract the core content. Due to incomplete or invalid responses, the valid sample size varies slightly across different dimensions in the statistical analysis.

4. Results and findings

4.1. Comparative case description

The research participants of this study were two parallel classes from Grade 1 and two parallel classes from Grade 4 at a primary school in a first-tier city along the southeastern coast of China. The teaching content for Grade 1 was Comparison of Numbers Within 100, and the teaching content for Grade 4 was Distributive Law of Multiplication.

In the Grade 1, Class 2, Grade 1 served as the experimental group, which adopted anchored instruction. During the class, the teacher verbally presented a situation asking students to compare the number of students in Class 3, Grade 1 (42 students) and Class 4, Grade 1 (37 students), and raised the "anchor" question: when comparing the two numbers, if digit 4 and digit 3, and digit 2 and digit 7 are compared separately, each side has an advantage—how can a correct comparison and judgment be made? Through group cooperation and hands-on practice by manipulating counters, students communicated within their groups, and naturally constructed the concepts of place value and number composition. Meanwhile, Class 4, Grade 1 served as the control group, which adopted traditional teaching. The teacher directly taught the knowledge of comparing numbers within 100, provided examples for students to calculate, and then conducted consolidation exercises with multiple problems.

In the Grade 4 classes, Class 4, Grade 4 served as the experimental group. The teacher presented a situational anchor about calculating the total cost of class uniforms, asked students to list expressions, compute the total price in different ways, and guided them to summarize and understand the meaning and structure of the distributive law of multiplication. Class 3, Grade 4 served as the control group. The teacher listed multiple arithmetic expressions of the distributive law of multiplication, provided calculation rules, and assigned corresponding example exercises for students to practice

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4.2. Contrast in student engagement

The M values of the experimental group and the control group in the three dimensions except the behavioral engagement dimension are all greater than 4.0. For the behavioral engagement dimension, it was reverse-coded, where lower scores indicate higher concentration and fewer off-task behaviors. No significant differences were observed in most dimensions except behavioral engagement.

Consistent with this, teacher Zhang notes that "Primary school students are becoming increasingly intelligent nowadays. Even with traditional lecturing, as long as teachers lecture clearly and correctly, they can keep up. However, the "novelty" of the anchored approach lies in that they feel they are "playing with mathematics" and learning in level-breaking games."

The behavioral engagement is the only dimension in which the M values of the two groups are less than 4 and show a statistically significant difference. A moderate effect size was observed (Cohen's $d = 0.40$), indicating that the difference in behavioral engagement between the two groups is practically meaningful. The result that the experimental group ($M=2.79$) scored significantly lower than the control group ($M=3.51$, $p<0.001$) effectively addresses academic concerns about the "seductive details" of anchored instruction. The lower mean score of the experimental group reflects that students can effectively filter irrelevant distractions and maintain concentration in class. This result can be attributed to the localized adaptation of anchored instruction, in which streamlined and focused content in micro-situations fundamentally reduces the possibility of students' distraction. In addition, a comparison grouped by grade was conducted, and the results showed that although the inter-group differences in all dimensions did not reach the significant level ($p>0.05$) and there were no essential statistical differences, educationally meaningful trends were found through descriptive statistics (mean values) and qualitative observations, and the mean scores of first-grade students in affective engagement and transfer application were both higher than those of fourth-grade students.

In terms of affective engagement, the core of anchored instruction is to create realistic and concrete anchored situations. "Anchors" such as hands-on group practice and reflection on specific mathematical knowledge in daily life can quickly stimulate the curiosity and interest of first-grade students and improve their affective engagement in class. However, the learning motivation of fourth-grade students is gradually transforming into achievement motivation, and they tend to focus more on in-depth understanding of knowledge rather than the introduction and initial learning of knowledge.

As for transfer application, anchored instruction realizes knowledge transfer based on anchored situations. In localized anchored instruction featuring "micro-situations", teachers deliberately select low-complexity "anchors" close to students' daily lives to avoid students' cognitive overload. This design naturally conforms to the cognitive development characteristics of lower-grade students in the early stage of concrete operational thought. Taking familiar life scenarios as carriers, it builds a "lightweight" scaffold for students' knowledge transfer, which explains the higher subjective scores of first-grade students in transfer application. In contrast, fourth-grade students are gradually developing abstract thinking and facing greater academic pressure, which weakens the appeal of such situations to them.

Meanwhile, front-line teachers pointed out in interviews that the effectiveness of anchored instruction is related to students' grades, hinging on the appropriate design of anchored situations. As interviewed teachers stated, "Whether anchored instruction is popular among students depends largely on the fit of anchor design. Situations for Grade One and Grade Two mainly adopt picture books and animations, which attract young students, while the same anchors will be regarded as childish by students in Grade Five and Grade Six." This view is highly consistent with the laws of

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students' cognitive development. Vivid situations such as picture book stories are widely accepted and close to the life experience of lower-grade students, reducing the difficulty of knowledge transfer.

Table 1. Results of independent-samples t-test

Dimension	Group	N	M	SD	t	df	Sig. (2-tailed)
Emotional Engagement	1	80	4.13	0.83	-0.21	156	0.836
	2	78	4.16	0.92			
Behavioral Engagement	1	77	2.79	0.80	-4.99	145.98	0.000
	2	77	3.15	0.98			
Cognitive Construction	1	80	4.23	0.95	-0.04	156	0.970
	2	78	4.23	0.99			
Transfer and Application	1	80	4.07	0.93	0.33	155	0.742

Note: 1 = Experimental Group, 2 = Control Group.

$p < 0.05$, $p < 0.01$, $p < 0.001$. The experimental group received anchored instruction, while the control group received traditional instruction. Levene's test for homogeneity of variance showed that variance was heterogeneous only for the behavioral engagement dimension ($p < 0.05$), and thus adjusted t-values were used. Variances were homogeneous for the other dimensions ($p > 0.05$), meeting the assumptions of the independent-samples t-test.

Table 2. Results of independent-samples t-test across different grades

Dimension	Group	N	M	SD	t	df	Sig. (2-tailed)
Emotional Engagement	Grade 1	41	4.28	0.89	1.67	78	0.099
	Grade 4	39	3.97	0.74			
Behavioral Engagement	Grade 1	40	2.84	0.80	0.51	75	0.609
	Grade 4	47	2.74	0.80			
Mean Score of Cognitive Construction	Grade 1	41	4.22	1.04	-0.05	78	0.958
	Grade 4	39	4.23	0.87			
Mean Score of Transfer and Application	Grade 1	41	4.15	0.89	0.76	78	0.448
	Grade 4	39	3.99	0.98			
Mean Score of the Current Lesson	Grade 1	40	3.88	0.62	0.89	74	0.378
	Grade 4	37	3.76	0.55			

Note: $p< 0.05$, $p < 0.01$, $p < 0.001$. The experimental group received anchored instruction, while the control group received traditional instruction. Levene's test for homogeneity of variances indicated that variances were heterogeneous only for the behavioral engagement dimension ($p < 0.05$), so adjusted t-values were adopted. Variances were homogeneous for all other dimensions ($p> 0.05$), satisfying the assumptions of the independent-samples t-test.

4.3. Contrast in knowledge construction

As for the perceptions of anchored instruction, all three teachers spontaneously pointed out in the interviews that original anchored instruction belongs to largeproject teaching, and the design of

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anchored situations particularly consumes time, human resources, energy, and material resources. Under practical pressure related to teaching input–output ratios and scheduled class hours, Teacher Chen stated that "it is almost impossible for an individual frontline teacher to implement fully traditional anchored instruction on a regular basis." Meanwhile, the situational design in anchored instruction has obvious timeliness and cannot achieve permanent applicability. Several teachers indicated that even carefully adapted anchors cannot be directly reused after two to three years; they fail to maintain suitability and lose situated authenticity and instructional value.

Apart from that, group cooperation serves as an important supportive strategy in the localized adaptation of anchored instruction in China. Frontline teachers often classify students into four ability levels labeled A, B, C, and D according to learning ability, verbal organization, and handson performance, and then form balanced cooperative groups accordingly. Such groups play essential roles in classroom management, academic support, classroom inquiry practice, and cognitive transformation, representing critical cultural adjustments and practical innovations that enable anchored instruction to fit local Chinese classrooms.

Finally, regarding the regular implementation of anchored instruction, the teachers regarded collective lesson preparation based on shared online resources as an indispensable measure. Collective investigation, discussion, and collaborative refinement of anchored situations within teaching research groups effectively reduce instructional design burdens, especially for novice teachers and firsttime practitioners of this model. Nevertheless, the teachers also noted that anchored instruction cannot be applied in a completely unified and standardized manner. Teacher Zhang admitted that "in teaching the topic of parallelograms, my emphasis lies in the core concept of equal opposite sides, so I devote substantial time to guiding conceptual exploration, whereas other teachers prioritize understanding and applying the height of parallelograms due to its status as a key examination point." Due to divergent instructional emphases and actual classroom arrangements across teachers, identical anchored situations cannot be copied mechanically and must be adjusted flexibly according to concrete student conditions and teaching progress, which creates certain difficulties in promoting the normalized application of anchored instruction.

4.4. Critical reflections on implementation

Through classroom observation and teacher interviews, it can be found that whether in higher or lower grades, obvious Matthew effects (the strong get stronger, the weak stay weak) exist among students in the same class, showing a differentiation phenomenon in which superior students become better while underachieving students remain weak. Teacher Zhang admitted that approximately one quarter of the students in each class cannot keep up with the learning progress or understand the assigned learning tasks.

Taking the classroom observation conducted in Grade One as an example, students at different levels showed significant differences in performance. Highachieving students could quickly grasp the core principle of number comparison, namely comparing tens digits first and then ones digits, and understand number composition and numerical relationships accurately and efficiently. In contrast, moderately disadvantaged and underachieving students showed obvious learning deficiencies. Most of them only mechanically memorized test-taking skills such as checking tens digits and easily confused mirrored place values, for example reversing and comparing numbers such as 74 and 47. Although they completed concrete operations with counters in class, they failed to transform practical procedures into abstract mathematical thinking and could not clearly verbalize reasoning methods for number comparison.

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This indicates that such students cannot achieve a genuine transformation from concrete perception to abstract understanding within a single lesson and require repeated practice and consolidation through subsequent courses, assignments and assessments. Such gaps in cognition and understanding will continue to accumulate and further intensify academic stratification among students, which also suggests that stratified and reasonable design is required in constructing anchored situations in anchored instruction.

5. Conclusion

5.1. Discussion of findings

This study was conducted in authentic primary mathematics classrooms in China and found that anchored instruction has undergone adaptation and transformation different from traditional anchored instruction in the localized teaching environment of China. In terms of situation setting, teachers generally adopt micro-situation design, which can be more closely aligned with teaching tasks, quickly enter the mathematics situation before children's attention declines rapidly [17], effectively deal with students' cognitive overload, and save teachers a lot of workload. At the level of group cooperation, the organic combination of students at different levels in joint exploration enables primary school students to ask and answer questions mutually in inquiry and help each other progress in practice, which is one of the important ways for the efficient operation of primary school classrooms.

5.2. Optimization paths

In view of the specific teaching background in China and the stratified learning abilities of students, several operable optimization measures are proposed based on actual classroom investigations and qualitative interviews.

As for the design of teaching "anchors", adopting a microsituation model is essential. Considering practical factors such as limited class hours, academic pressure and teaching requirements in primary schools, overly complicated and timeconsuming "anchored situations" not only increase teachers' teaching pressure but also raise the learning burden of underachieving students. Concise, focused and liferelated microsituations can lower cognitive barriers and match the cognitive level of most students. Meanwhile, they free teachers from complicated situation design, allowing them to focus more on students' realtime classroom performance and their understanding, absorption and transformation of knowledge after class.

Apart from that, it is necessary to further strengthen the cooperative learning model and give play to the advantages of peer assistance among students. When peers with similar cognitive levels and thinking styles learn interactively as colearners, this solves the practical problem that those teachers cannot provide full guidance to every student in class. The high-achieving students are able to gain more knowledge by expounding on the points of knowledge and the students, who are underachievers, are able to take risks and learn in a relaxed peer environment, clarify on the learning tasks and slowly follow the learning process. The suggestion is an efficient tool in reducing the Matthew effect as well as adjusting to stratified student groups, and is additionally the tangible execution of the student centered educational philosophy in the primary mathematics classroom.

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5.3. Limitations and future work

The paper does possess a few shortcomings. To begin with, the sample of the questionnaires is restricted to Grade One and Grade Four students in one school whereas the sample size is quite small. Second, because of the limitations imposed by teaching arrangements, the data collection period was relatively short, and there were no long-term monitors of the learning outcomes of the students.

Further research in the future can extend the range of samples and draw the students of alternative schools and other grades level to provide comparison. In the meantime, one semester or one academic year systematic teaching interventions ought to be embraced to continue investigating the localized transformation model and the long term aftermath of the anchored instruction on primary school mathematics. This is capable of giving stronger real-life evidences on the teaching practice in primary school mathematics in China.

5.4. Final concluding remarks

This study shows that the overall implementation effect of anchored instruction based on micro-situations is equivalent to that of the traditional teaching model, and the core of this paper is not to verify the advantages and disadvantages of the teaching model itself, but to identify the practical necessity of adjusting and reconstructing anchored instruction under the localized classroom environment in China.

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