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A Study on Teaching Design Strategies of Secondary School Mathematics Classroom Based on the Cultivation of Mathematical Core Literacy

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Abstract

In recent years, the educational landscape has progressively underscored the holistic developmental trajectory of students, with a particular emphasis on the reformation of secondary school mathematics curricula to bolster mathematical literacy. This research delves into the prevailing issues inherent in the design of secondary school mathematics classrooms, positing enhancements through the creation of an engaging learning milieu and fostering interactive, cooperative inquiry. The findings delineated that such pedagogical strategies significantly nurture divergent thinking, analytical acumen, and innovative consciousness among secondary students, thereby facilitating the actualization of core mathematical literacy within the classroom milieu. Prospective research endeavors will aim to meticulously evaluate the efficacy of these strategies through rigorous empirical scrutiny.

Keywords: Core Literacy, Mathematical Core Literacy, Secondary School Mathematics Classroom, Teaching Design Strategies, Classroom Instructional Design

Introduction

In recent years, the concept of core literacy has emerged prominently in the educational domain, becoming a widely discussed and regarded topic across various societal sectors (Li et al., 2023). Indeed, core literacy has progressively positioned itself as a new focal point in global basic education reform, playing a crucial role in deepening the reform of basic education curriculum and achieving the objectives of quality education (Wang, 2020; Zhu, 2023). In 2016, the document "Research on Core Literacy for 21st Century Student Development" elucidated the essence of students' core literacy,which stated:

> *The core literacy for student development primarily refers to the fundamental qualities and key abilities that students should possess to adapt to lifelong and societal developmental demands. Core literacy embodies the holistic manifestation of students across various dimensions such as knowledge, skills, emotions, attitudes, and values. It represents the common literacy indispensable for each student to attain a successful life, adapt to personal lifelong development, and societal evolution. The cultivation of core*

literacy is a continuous, lifelong process, amenable to teaching and learning, initially nurtured within the realms of schools and families, and subsequently refined throughout an individual's lifetime (Lin, 2016).

Within the continuum of individual development, foundational literacy serves as a linchpin for adeptly navigating a myriad of life scenarios. Among these, the most quintessential and indispensable are encapsulated under the umbrella term "core literacy." Core literacy epitomizes a holistic amalgamation of knowledge, competencies, dispositions, and values. It encompasses "cognitive literacy" attributes such as problem-solving acumen, inquiry capabilities, and critical thinking prowess, alongside "non-cognitive literacy" facets including self-management, organizational adeptness, and interpersonal dexterity (Kim, 2019).

In the nascent years of the 21st century, the international echelon delineated a structural model for core literacy (Desjardins, 2004), catalyzing the evolution and nurturing of core literacy to burgeon as a ubiquitous ideology for talent cultivation across the global tapestry. This paradigm shift, emblematic of a collective trend within the global educational arena, emerges in response to the escalating international competition. The contemporary educational domain, amidst this competitive milieu, grapples with substantial challenges, concurrently experiencing a surge in societal expectations for individuals' comprehensive aptitudes (Yao & Guo, 2018). The edifice of the core literacy framework resonates with the overarching trajectory of prevailing international educational reforms (Moss, 2009), harboring the potential to significantly augment the caliber of talent development, and thereby, markedly fortifying a nation's core competitiveness.

The advent of the core literacy framework provides a more precise direction for the formulation of school curriculum objectives, enabling a better adaptation to the developmental needs of students at different age stages, thereby propelling the scientification of curriculum objectives (Yao & Guo, 2018). Consequently, within the school classroom environment, particularly in secondary school classrooms, higher demands are placed on teachers' professional competencies and instructional capabilities. Teachers ought to discard the traditional classroom role positioning, actively engage in instructional role transformation, efficiently organize classrooms, and reasonably guide students' thinking and learning (Yu & Chen, 2023). Moreover, teachers should foster collaboration between students and themselves, orchestrating students in inquiry-based learning, cooperative learning, and autonomous learning (Toppel, 2015). Through the transformation of the teacher's role, on one hand, the efficiency of classroom instruction can be enhanced, facilitating students in mastering and applying knowledge; on the other hand, it can also imperceptibly cultivate students' core literacy, ignite students' enthusiasm for learning, and enable students to become the protagonists of learning.

Since the mid-20th century, the discourse surrounding mathematical literacy has progressively garnered the attention of scholars (Beckmann, 1954; Fawcett, 1947). The conceptual understanding of core mathematical literacy has traversed a developmental continuum, evolving from a plethora of disparate perspectives towards a more harmonized comprehension. During the epoch spanning the 1960s to 1970s, albeit the term "mathematical literacy" remained nebulous, a myriad of semantically analogous terms emerged to delineate related conceptual frameworks (Hopkins & Berry, 1961; William Beckmann, 1970); notwithstanding, a unified conceptualization remained elusive during this juncture. Emanating from the United States, Professor J. Zacharias pioneered the term "quantitative literacy," encapsulating the quintessential aptitude requisite for citizens to adeptly navigate issues and discourses pertinent to individuals, nations, and the global

tableau. This encompassed domains such as arithmetic, the real number continuum, rudimentary measurements, graphical and cartographic representations, rates of change, and statistical distributions (Zacharias, 1974).

Nonetheless, during this nascent stage, the scholarly understanding of mathematical literacy was predominantly tethered to mathematical computation. As the discourse transitioned into the 1980s and 1990s, research scholars commenced a closer juxtaposition of mathematical quandaries with real-world scenarios, thereby continually broadening their investigative domains. Through meticulous exploration, scholars incrementally honed their comprehension of core mathematical literacy. L.A. Steen, in a seminal exposition, extrapolated the scope of mathematical literacy into practical mathematical literacy, civic mathematical literacy, professional mathematical literacy, leisure mathematical literacy, and cultural mathematical literacy, predicated on value orientation (Steen, 1990). Although, at this juncture, the scholarly understanding of mathematical literacy had burgeoned from a singular computational realm to encompass a broader spectrum of practical application, a relatively unified conceptual framework remained elusive. This lacuna galvanized expert scholars to perpetuate their investigative endeavors into this field in ensuing epochs.

As the 21st century unfurled, accompanied by the swift advancement of the epoch alongside metamorphoses in the economic and technological spheres, the essence of mathematical literacy witnessed a continual expansion, culminating in a relatively harmonized understanding on an international scale. In the year 2000, the Australian Practical Survival Skills Survey amalgamated the categories pertinent to numerical competencies requisite for navigating life and work challenges under the aegis of mathematical literacy (Tout, 2000). Subsequently, Zhang et al. (2004) construed mathematical literacy as a manifestation of mathematical thinking prowess, encompassing mathematical operational acumen, logical thinking capability, and spatial imaginative faculty, among which logical thinking capability was heralded as the core. Cao Wenxi (2017), amidst the course revision trajectory, elucidated the composition of mathematical core literacy, delineating six facets: mathematical abstraction, logical reasoning, mathematical modeling, mathematical operation, intuitive imagination, and data analysis. These six facets, albeit autonomous, are intricately interwoven, coalescing into a tightly-knit whole, epitomizing the quintessence and intellectualism of mathematics, and are incrementally cultivated through the odyssey of mathematical learning. Ergo, within the milieu of middle school mathematics classrooms, the infusion of mathematical thought into students, kindling students to employ mathematical thought in the formulation of mathematical models, and orchestrating analysis and computations to augment students' mathematical literacy, have ascended as paramount considerations that educators cannot eschew in classroom design.

Consequently, individuals are necessitated to hone the aptitude for lifelong learning to adeptly acclimate to societal metamorphoses, ensuring they remain contemporaneous and attain lifelong development (van Merriënboer et al., 2009). Mathematical core literacy epitomizes the indispensable competencies learners must harbor to flourish within society, leveraging acquired knowledge to navigate real-world quandaries encountered (Jovanova-Mitkovska & Hristovska, 2011). It signifies a comprehensive acumen of particular import that students should garner through the odyssey of learning mathematics. Hence, mathematical core literacy should command profound attention from both educators and learners throughout the instructional continuum. The nurturing of students' mathematical core literacy is anchored in mathematical knowledge and prowess, and manifests in the application of such knowledge and prowess to problem-solving endeavors. It encapsulates the

quintessence of mathematics and the corollary mathematical ideations. This mandates students to incessantly experience, incrementally amass, scrupulously contemplate, and flexibly deploy the acquired knowledge throughout the trajectory of learning mathematics.

The cultivation of students' mathematical core literacy serves as a conduit for expanding their intellectual vistas, ensuring that their engagement with mathematics transcends the mere comprehension and application of sterile mathematical formulae, as well as the mechanical execution of complex calculations (Banilower et al., 2006). It mandates students to scrutinize problems holistically through a mathematical prism, and ingeniously deploy acquired knowledge in concert with diverse methodologies to efficaciously resolve mathematical conundrums (Firdaus et al., 2017). Concurrently, this emerges as a significant avenue for educators to augment their professional competence, engendering collective ascension in ideological, professional, and instructional capacities. Mathematical core literacy envelops multiple dimensions encompassing mathematical thinking, values, and skills, mirroring the cultural ethos of mathematical learning and underscoring the import of mathematical emotions and awareness.

More saliently, the nurturing of students' mathematical core literacy can expedite the trajectory of educational curriculum reform on a global scale (Sahlberg, 2006), further honing the educational curriculum architecture, and actualizing quality education across scholastic institutions at all echelons. This insinuates a paradigm shift in educational reform from erstwhile monolithic teaching models, accentuating the cultivation of students' core literacy. The active exploration and development of curricula conducive to fostering a mathematical culture and innovative practical aptitudes, coupled with the investigation of "collaborative inquiry-based" classroom models (Lu et al., 2021), will also be instrumental in the edification of a novel curriculum system.

This research, contextualized within the milieu of secondary school mathematics pedagogy during the foundational education phase, probes the quandaries inherent in the contemporary enactment of secondary school mathematics instruction, with a particular focus on analyzing the disengagement mentality pervasive among secondary school students. Subsequently, this investigation embarks on a re-construction and design of the secondary school mathematics classroom, endeavoring to ameliorate students' disengagement mentality and enhance the caliber of instruction. Ultimately, this research delineates the specific manifestations of cultivating students' mathematical core literacy through classroom design in secondary school mathematics instruction. The findings of this research will furnish invaluable references for practitioners within the foundational education sphere, assisting in effectively augmenting the quality of instruction and nurturing students' mathematical core literacy, thereby catalyzing the sustainable development of foundational education, particularly within the domain of mathematics education.

Analysis of the current state of the secondary school mathematics classroom

The Importance of the Secondary School Mathematics Classroom

The classroom, epitomized as the quintessential organizational nexus of school educational endeavors (Abdumutalibovich & Ganeshina, 2022), emerges as the primary conduit for knowledge dissemination, ability cultivation, and holistic augmentation of student quality. It also manifests as a pivotal channel for actualizing quality education among secondary school students (Zenda & Dlamini, 2023). Within this milieu, students are afforded the opportunity to assimilate knowledge, hone diverse abilities, and nurture the consciousness indispensable for personal growth and development. Therefore, in secondary school mathematics

classrooms, pedagogy should underscore the cultivation of students' thinking faculties (Abu et al., 2017; Innabi & Sheikh, 2007). Educators should adeptly leverage their pedagogical acumen to catalyze intellectual synergies both between teachers and students, and among the students themselves, metamorphosing classroom instruction into a vibrant forum for intellectual exchange. However, upon reflection on traditional classroom pedagogy, it is often observed that educators may rigidly adhere to established norms, orchestrating a unidirectional knowledge transmission in alignment with curriculum standards. This modality, with its sole emphasis on conclusions whilst eclipsing the process, culminates in students' incomplete assimilation and digestion of knowledge, rendering them with a superficial grasp bereft of underlying comprehension.

As educators, the adage of teaching one to fish, rather than merely providing the fish, holds profound resonance. Within the realm of secondary school mathematics instruction, the elucidation of ideas and methodologies employed in the analytical process should be manifest either verbally or through board inscriptions, shepherding students to analyze, discourse, and collectively appreciate diverse perspectives (Conner et al., 2014). This pedagogical approach facilitates students in understanding and assimilating knowledge amidst the process of cogitation and exploration, concurrently enhancing their comprehensive mathematical aptitudes. The triumph of a mathematics lesson is not solely tethered to the educator's ability to elucidate concepts with thoroughness or to impart pertinent knowledge and problem-solving methodologies to students. It is also significantly intertwined with students' earnest engagement, participation in classroom dialogues, discussions, and collaborative endeavors (Adnan, 2017; Howe et al., 2019). Therefore, educators should remain in stride with the evolving educational tableau, proactively orchestrating and organizing classroom activities. This empowers students to engage in the classroom as active agents, invigorating their learning initiative and permitting them to savor the joy of learning, particularly the pleasure derived from the odyssey of learning mathematics.

Problems in Secondary School Mathematics Classrooms

The contemporary domain of secondary school mathematics education continues to harbor myriad issues, which not only stifle students' innovative thinking but also impede their holistic development. For instance, a notable number of schools exhibit a predilection for humanities over sciences, channeling a substantial quantum of effort and resources into the pedagogy of language and English disciplines, thereby imposing elevated expectations upon students (Altbach, 2013; Rosinger et al., 2016). This practice culminates in students being bereft of adequate time to exercise mathematical thinking and accrue mathematical methodologies, consequently attenuating their mathematical core literacy (Ökördi & Molnár, 2022). This scenario is inauspicious not only for augmenting students' mathematical performance but also for nurturing their ability to leverage mathematical knowledge and techniques in solving real-world conundrums. Additionally, within the confines of secondary school mathematics classrooms, teachers often neglect the infusion of mathematical culture in teaching, failing to delve into and impart the essence of mathematical culture, opting instead for a superficial treatment (Boaler, 2015). Furthermore, with the escalation of academic advancement pressure, students are encumbered with an augmented load of homework (Su, 2016), which could potentially adversely impinge upon their physical and mental health growth.

Psychological Analysis of Mathematics Anorexia in Secondary School Students

The nexus between an individual's physiological and psychological development is profoundly intricate (Fisher, 1986). The maturation of physiological functions can catalyze psychological maturity, and reciprocally, psychological advancement can foster physiological maturation (Wang & Fu, 2023). Throughout the entire ontogenetic trajectory of an individual, the cadence of physiological and psychological development necessitates harmonization to coalesce into a relatively rational whole, ensuring the individual's physical and mental development perpetually maintain a balanced and stable state (Yang & Yu, 2023). The secondary school stage epitomizes an exceedingly unique and pivotal phase in the individual growth process, and is also heralded as the golden epoch for secondary school students' growth. Physiologically, the velocity of development during this stage is particularly brisk, culminating in the maturation of various bodily functions within a succinct span of time. However, psychologically, secondary school students often manifest a relatively languid development pace; juxtaposed against adults, they may appear less mature and decisive in cognitive and problem-solving endeavors. During the secondary school period, owing to the unbalanced state of students' physical and psychological facets (Geverola et al., 2022), this may precipitate the accentuation of various contradictions in the psychological development process, thereby morphing into obstacles on the pathway of healthy growth for secondary school students.

Recent survey data elucidates that 32% of first-year junior high students harbor a disdain for mathematics, a proportion that burgeons to 45% and 58% among second-year and third-year students respectively (Andersson, 2022). Upon meticulous analysis, several salient factors have been identified as culprits for this scenario: Firstly, proficient educators and students tend to transition from rural junior high schools to urban institutions, adversely impacting the pedagogical quality in rural schools. Secondly, rural junior high schools exhibit a higher proportion of academically lagging students; by the third year, 60% of students are unable to keep pace with the learning trajectory, whilst teaching often caters exclusively to a minority of high-achieving students. Thirdly, due to generally inferior economic conditions in rural households vis-à-vis urban ones, urban students often revel in the advantages of home education, a privilege scarcely afforded to rural students. Fourthly, the relatively lower educational echelon of rural parents culminates in students lacking comparable knowledge support at home as their urban counterparts. Fifthly, numerous rural parents necessitate working away from home, leading to a dearth of requisite parental discipline for many students, thereby exacerbating students' aversion to learning and significantly impeding the enhancement of pedagogical quality (Butcher, 2023). To augment the efficacy of junior high mathematics classroom pedagogy, alleviating students' aversion to learning is of paramount importance. By identifying and addressing the aforementioned issues, effective measures can be employed to ameliorate the pedagogical environment and quality in rural junior high schools, thereby elevating students' learning enthusiasm and pedagogical outcomes.

In consonance with the overarching objectives and fundamental tenets of the new curriculum, educators are enjoined to rejuvenate their perspectives and transition their roles (Thompson, 2020). Hence, only through the adoption of a "student-centered" instructional design theory can a natural and harmonious classroom milieu be cultivated (Reusser, 2020), enabling students to engage in autonomous learning within the classroom and revel in the joy of learning. Within the domain of secondary school mathematics instruction, educators should leverage a plethora of resources and employ a myriad of innovative and efficacious methodologies to ignite students' enthusiasm for learning mathematics, significantly alleviate

students' aversion to learning, and facilitate the study of mathematics in a relaxed and enjoyable ambiance. Through this modality, not only can we nurture and elevate students' mathematical core competencies, but also construct a vibrant classroom instructional ecosystem.

Secondary School Math Classroom Design

Conceptualize the lesson beforehand and look at the material from the students' perspective

The triumph or tribulation of secondary school classrooms is inextricably entwined with the outcomes of implementing quality education. The classroom emerges as the quintessential organizational nexus of school educational endeavors, through which educators disseminate knowledge, cultivate students' learning habits, foster students' multifaceted abilities, and unearth students' comprehensive potential (Povinelli, 2023). Rich classroom content, a congenial classroom atmosphere, and notable classroom efficiency are pivotal constituents in our endeavor to actualize quality education amidst the new curriculum reform. Should educators fail to undertake ample preparation antecedent to the class, the entire classroom milieu might manifest as disorganized and lackluster, leading to diminished classroom efficiency and a consequent attenuation of students' interest in learning.

The new curriculum standards astutely accommodate the psychological characteristics of students at disparate stages of growth and development, providing more scientifically precise stipulations for teaching objectives across various educational phases. This mandates that educators, in formulating teaching objectives, meticulously consider the learning conditions of students, eschew reliance on any external materials, and scrutinize the teaching materials from the students' perspective and psychological standpoint. By adopting such an approach, educators can maximize the anticipation of learning conditions, garner invaluable "first impressions," and design the teaching process in a manner that is congruent with the students' cognitive and developmental profiles.

In traditional pedagogical segments, educators typically familiarize themselves with the content of the teaching materials, elucidate the knowledge nodes to be imparted along with the pivotal and challenging points, and then orchestrate them judiciously. However, the conventional lesson preparation methodology often overlooks the value orientation inherent in the subject of mathematics, rendering it arduous to optimally cultivate students' core mathematical literacy within the classroom milieu. Taking the lesson on Understanding Inequalities as an exemplar, there might manifest significant disparities in the scrutiny of teaching materials between seasoned senior educators and nascent educators who are newly initiated to the podium. The teaching objectives of these disparate groups can be juxtaposed through the following Table 1:

Aspect	Experienced Teacher's Objective	Young Teacher's Objective
Conceptual Understanding	To ensure students grasp the fundamental principles and properties of inequalities.	To introduce the basic concept of inequalities to students.
Procedural Skills	To teach students the methods and steps of solving inequalities.	To guide students through the process of solving simple inequalities.
Application	To demonstrate the real-world applications of inequalities and encourage students to apply the learned concepts in practical scenarios.	To provide examples of how inequalities are used in everyday situations.
Critical Thinking	To stimulate students' critical thinking by presenting complex inequality problems and encouraging discussions.	To encourage students to think critically by asking open-ended questions related to inequalities.
Value Orientation	To instill an appreciation for the logical beauty and practical utility of mathematics through the topic of inequalities.	To foster a positive attitude towards mathematics by making the lesson engaging and relevant.

Table 1 Comparison of Differences in Teaching Objectives for Recognizing Inequalities by Teachers with Different Experiences

Indeed, seasoned educators are capable of examining teaching materials from the students' perspective, delving into the implicit mathematical ideas and methods therein. By aligning with students' actual conditions and the current status of societal development, they can design more targeted teaching objectives, thereby enriching the teaching goals beyond a singular focus to a more diversified spectrum. Through the three dimensions of knowledge skills, process methods, and emotional attitudes, they can deeply explore the mathematical ideas embedded behind each lesson, thereby holistically nurturing students' core mathematical literacy.

The seasoned educators' approach reflects a more nuanced understanding of the multifaceted nature of mathematical learning. It transcends the mere acquisition of procedural skills to encompass a broader exploration of the intrinsic value and applicability of mathematical ideas. This holistic approach, grounded in real-world relevance and students' personal experiences, not only enriches the learning process but also fosters a more profound appreciation and understanding of mathematics among students (Bassachs et al., 2020).

Moreover, by intertwining societal context and students' practical circumstances within the teaching objectives, seasoned educators can render the learning experience more relevant and engaging for students (Jiang et al., 2022). This relevance, in turn, amplifies students' motivation and interest in mathematics, which are quintessential for cultivating their core mathematical literacy. Furthermore, the emphasis on emotional attitudes underscores the importance of fostering a positive learning milieu. By addressing students' emotional responses to mathematics and crafting a supportive, enjoyable learning atmosphere, educators can significantly impact students' attitudes towards the subject, which is a vital aspect of nurturing their core mathematical literacy.

In summary, the seasoned educators' approach, characterized by a student-centered, value-oriented, and holistic perspective, proffers a more effective and enriching pathway for cultivating students' core mathematical literacy. Through this approach, educators can better equip students to appreciate, understand, and utilize mathematics in their academic pursuits and daily lives.

Create a learning situation to introduce the classroom, stimulate students' learning motivation

Educational interaction is a cardinal requisite for the implementation of quality education and the infusion of innovative educational paradigms. It also serves as a significant reflection of an educator's prowess in classroom management, guidance, and stimulation of students' interest and motivation, alongside fostering students' individuality (Yang et al., 2020). In secondary school classroom pedagogy, educators should actively collaborate with students to identify quandaries, explore the mathematical models underpinning real-world issues, and collectively endeavor to ascertain appropriate methodologies to resolve mathematical problems. This not only cultivates students' core mathematical literacy through educational interaction but also fully embodies the reciprocal benefits of teaching and learning.

In recent years, pivotal core concepts in the educational domain, such as quality education and innovative education, have progressively transitioned from theoretical frameworks to practical applications, being robustly integrated into teaching practices (Zhao & Zhang, 2021). Novel interactive teaching methodologies, such as discussion-based and case-based approaches, have been harnessed by secondary school educators in mathematics classroom pedagogy, garnering positive feedback from both educators and students. However, due to the inertial influence of traditional mathematical teaching ideologies, some interactive teaching has metamorphosed into formalized engagements, with suboptimal interactive effects, failing to play a constructive role in classroom pedagogy.

In secondary mathematics classrooms, the objective of teacher-student interaction often merely serves to embellish the teaching process, stagnating at the level of simplistic "yes or no" or "right or wrong" queries, or pure memorization of quantitative concepts, definitions, theorems, and formulas. These interactions are mechanical and do not reflect the cultivation of students' core mathematical literacy, and should thus be eschewed in contemporary classroom pedagogy.

The esteemed ancient Chinese educator, Confucius, posited that those who harbor a love for knowledge are elevated compared to those who merely possess it. This aphorism underscores that within the educational trajectory, students' zeal for learning is a fundamental precursor for mastering knowledge, and can significantly augment students' assimilation of knowledge. As secondary mathematics educators, it is imperative to integrate relevant educational and psychological theories, amalgamate them with actual teaching practices, utilize "interest" as a compass, and "emotion" as a navigational tool to kindle students' interest in learning mathematics, invigorate students' enthusiasm for mathematical exploration, and instill a fervor for learning. Consequently, educators should accord particular attention to the introductory segment of the classroom, design interactive components, galvanize students' enthusiasm, and stimulate students' interest in delving into mathematical inquiries. This not only fulfills the fundamental requisites of quality education but also serves as a pivotal avenue for nurturing students' core mathematical literacy. By facilitating students to observe and analyze, and to engage in reflective questioning, students can seamlessly intertwine mathematical knowledge and methodological thinking with real-world quandaries, employing knowledge and methodologies to resolve problems.

With the relentless advancement of science, particularly the deepening exploration in psychological research, the erstwhile revered behaviorist learning theory, which was perceived as axiomatic by educators, is gradually being supplanted by constructivist learning theory. Behaviorist learning theory accentuates stimulus-response dynamics, which manifest in classroom pedagogy as a unilateral transmission of knowledge from educator to student, treating students as mere receptacles of knowledge. However, with the continuous deepening of the new curriculum reform, the aspiration to metamorphose students' learning methodologies is intensifying, rendering the transformation in students' learning methodologies an exigent endeavor.

Educators must first thoroughly assimilate and comprehend the knowledge points, and endeavor to unearth the allure inherent within the knowledge, particularly in the realm of mathematics which extols logical reasoning and meticulous analysis (Wen, 2022). It is imperative for educators to adeptly employ corresponding pedagogical methodologies to impart knowledge, elucidate concepts comprehensively, and foster the formation of coherent knowledge networks among students. This, in turn, cultivates a zest for learning and augments the nurturing of core mathematical competencies. The distinguished educator, Bruner, once articulated, "The paramount catalyst for learning is an interest in the material." Indeed, within the trajectory of learning secondary mathematics courses, the corresponding knowledge often harbors intriguing facets that captivate secondary school students. Educators should adopt a student-centric approach, initiate from the textbooks, utilize knowledge points as the linchpin, delve deeply into the charm encapsulated within textbook knowledge, and ignite students' enthusiasm for autonomous and joyful learning.

Within the introductory segment of the classroom, educators should craft problem scenarios to kindle students' motivation for learning. The creation of problem scenarios propels students' thinking beyond the confines of the classroom, transporting their cognitive explorations to any realm that facilitates comprehension. This not only enhances students' attentiveness but significantly galvanizes their motivation to engage in critical thinking. Hence, educators should excel in transmuting those mundane and abstract teaching contents into a series of intriguing, captivating, and easily digestible problems, enabling students to savor the joy of learning through active contemplation of these problems. For instance, when elucidating *Radian Measure*, pose the query: What are the customary units of length measurement we typically employ? This approach amalgamates mathematical knowledge with practical daily life scenarios, arouses students' cognitive curiosity, and stimulates their interest and enthusiasm for learning. Upon students' responses regarding common units of length measurement such as meters, feet, and inches, proceed to inquire: How many feet constitute a meter, and how many inches comprise a foot? Through the mechanism of crafting problem scenarios, students can swiftly transition into a learning state, their motivation for learning is stimulated, and they are enabled to comprehend and learn the alternate measurement methodology of angle in this lesson, radian measure, through analogy. Most significantly, such scenario-based introductions enhance students' logical thinking acumen, the applicability of mathematical knowledge to real-life situations, and effectively nurture students' core mathematical literacy.

Classroom Active Collaborative Inquiry Goes to Eliminate Student Boredom

Cooperative learning signifies a departure from the traditional teaching model of teacher-led instruction to a more integrated approach, where the teacher acts as a facilitator in a collaborative inquiry, guiding students to collectively arrive at conclusions (Hennessy et al.,

2021). Through cooperative learning, students' communication, expression, teamwork awareness, and practical operation consciousness are honed to varying degrees. Simultaneously, it enables a division of labor and collaboration between teachers and students, addressing the shortcomings encountered in traditional individual learning processes where obstacles are hard to overcome by individual effort alone. By leveraging sincere cooperation among team members, engaging in mutual discussions, playing to each member's strengths while avoiding weaknesses, it helps to alleviate students' aversion to learning, ensuring that every individual's strengths become a vital part of the team. Currently, cooperative inquiry-based learning has become an inevitable trend in modern classroom teaching and is also the direction of future educational curriculum reform.

In the process of secondary school mathematics classroom teaching, teachers should not only convey fundamental knowledge to students but also consciously foster students' inquiry abilities through cooperative exploration. This approach is also an important means to enhance students' core mathematical literacy. Through such collaborative learning environments, students are encouraged to actively engage, discuss, and solve problems together, which not only enriches their understanding of mathematical concepts but also develops essential skills such as critical thinking, problem-solving, and effective communication. This shift towards a more interactive, student-centered learning environment is not only in line with modern educational trends but also crucial for preparing students for the collaborative nature of problem-solving in real-world scenarios (Nilimaa, 2023).

In teaching the topic of *Sum of Interior Angles of a Regular Polygon* in secondary school, teachers can organize students into small groups for cooperative inquiry-based learning. Through a step-by-step exploration from simple to complex, and from specific to general, students are guided to discover the quantitative relationship between the sum of interior angles and the number of sides in a regular polygon. Within their groups, students are encouraged to share their findings and perspectives, listen to the diverse thought processes and solution strategies of their peers, engage in discussions, learn from each other, and collectively summarize their explorations as the final outcome of the group inquiry. Through this process of cooperative communication, discussion, vigorous debate, and seeking common ground while respecting differences, students are further able to inductively derive the quantitative relationship between the sum of interior angles and the number of sides, thereby nurturing their core mathematical literacy.

Therefore, teachers should delve deeper into understanding students' psychological characteristics and learning traits from various angles and at different times. They should grasp the overall rationale behind the textbook compilation, align it with the actual teaching scenario, and tailor it to the real circumstances of the students. By meticulously and cleverly designing and organizing the cooperative inquiry-based learning segments in the classroom, teachers can ensure that the students' role as the primary learners is fully embodied in the mathematics classroom. This approach facilitates students in quickly, efficiently, and sustainably absorbing, understanding, mastering, and subsequently applying the knowledge. Through cooperative learning in the classroom, students' core mathematical literacy is genuinely enhanced and developed, making the learning experience more engaging, interactive, and conducive to deeper understanding. This method not only enriches the teaching of mathematical concepts but also fosters a collaborative learning environment that prepares students for real-world problem-solving scenarios, embodying a modern, student-centered approach to education.

Changing the traditional classroom model and enhancing classroom interaction

The prevailing teaching model in most classrooms remains the lecture-reception mode, where a 45-minute mathematics lesson primarily revolves around textbook-based teaching, rendering students passive in their learning process. The classroom atmosphere significantly impacts students' enthusiasm and initiative towards learning. Creating a lively, engaging, and enjoyable classroom environment can nurture students' interest in learning, establish good study habits, and develop effective learning strategies, thereby fostering a desire to learn, the ability to learn, and a love for learning.

Therefore, as secondary school mathematics teachers, the design of classroom teaching, particularly the formulation of questions within the classroom, becomes crucial. It's imperative to respect students fully, allowing them more autonomy in their learning. Teachers should refrain from instructing on concepts that students can understand on their own, and only provide guidance on those that students find challenging. In this scenario, teachers act as "watchers" and participants rather than mere dispensers of information.

For instance, when introducing the Pythagorean theorem, some teachers might simply draw a few right-angled triangles on the blackboard and expect students to observe and discover the relationship between the sides on their own. Such a teaching design lacks appropriate thought guidance and hints for students, coming off as relatively rigid and direct. Students often find themselves at a loss on how to proceed, which can dampen their enthusiasm for learning mathematics. This approach is not conducive to encouraging students to actively discover, collaboratively explore, and independently understand the relevant mathematical concepts and formulas.

A more effective approach could involve teachers facilitating a conducive environment for discovery and exploration. They could provide initial guidance, perhaps through interactive discussions or by presenting real-world problems that the Pythagorean theorem can solve. By doing so, teachers can spark curiosity, encourage collaborative inquiry, and guide students towards deriving the theorem themselves. This method not only makes the learning process more interactive and enjoyable but also empowers students to take charge of their learning, fostering a deeper understanding and appreciation of mathematical concepts.

A Comparative Study of Interactive Learning Cases on the Pythagorean Theorem

Now let's look at another design case by a veteran teacher with many years of teaching experience. Initially, through the display of images, students are invited to appreciate the beauty of shapes, sparking their interest. This leads to the introduction of the historical background related to the shapes, enabling students to understand the historical context of the Pythagorean theorem through the images and teacher's explanation. This naturally transitions into the topic of the lesson. Following this, a story is introduced:

Pythagoras, a renowned mathematician from ancient Greece, was invited to a friend's house one day. While relaxing after a meal, he suddenly noticed that the floor tiles in his friend's house exhibited a fascinating numerical relationship, reflecting a certain quantitative relationship among the three sides of a right-angled triangle.

Case 1:

(1) Please observe the Fig. 1, what can you discover from the floor tiles in Pythagoras' friend's house?

(2) Can you identify the relationship between the areas of the three different small squares in the image?

(3) Isosceles right-angled triangles are special right-angled triangles. Do all right-angled triangles possess the property that "the sum of the squares of the two legs equals the square of the hypotenuse"?

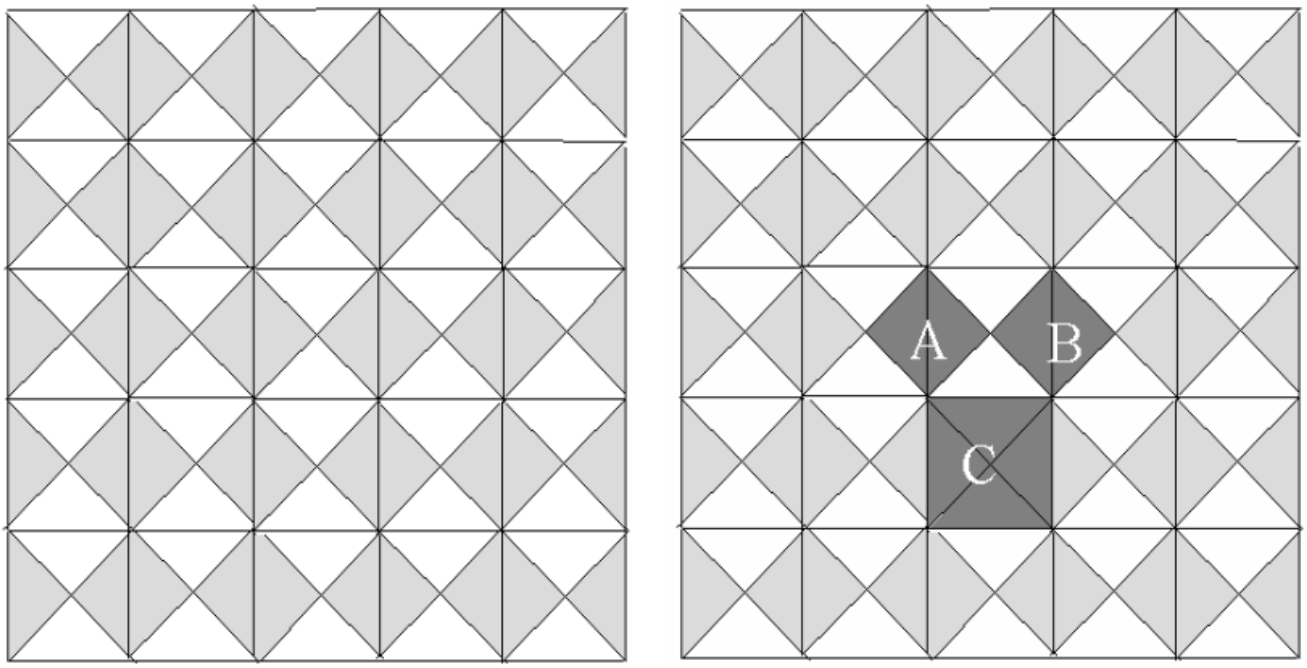

Fig. 1 Study of the Pythagorean Theorem on a floor made of floor tiles

The teacher displays the image and poses the question; students observe the shapes, analyze, and deduce the pattern, concluding: the sum of the squares of the two legs of an isosceles right-angled triangle equals the square of the hypotenuse. In this teaching design, the teacher effectively utilizes visual aids and storytelling to create a captivating narrative around the Pythagorean theorem. By doing so, the teacher not only makes the learning process more engaging but also provides a contextual framework that helps students better understand and appreciate the mathematical concept being introduced. The interactive nature of this teaching approach, where students are encouraged to observe, analyze, and deduce, promotes active learning and critical thinking, which are essential for grasping and applying mathematical principles.

Case 2:
Question: As shown in Fig. 1, three squares are drawn outwardly with the three sides of right-angled triangle ABC as their sides. Place the figure on grid paper. If the side length of each small square is denoted as "1", please find the area of the three squares in the figure. How did you obtain it? How do you calculate S_R? By calculating, do you find any relationship between the areas of the three squares?
To calculate the area of the three squares, you would measure the length of each side of the right-angled triangle ABC, square each length, and then count the number of small squares within each large square. For example, if side AB has a length of 3 units, the area of the square with side AB would be $3^2 = 9$ square units. Repeat this process for the other two sides of the triangle. SR could be a specific ratio or relationship you are looking to find, and its calculation would depend on the given information or the context of the problem. Upon calculating the

areas of the squares, you may discover the Pythagorean theorem, which states that in a right-angled triangle, the sum of the squares of the two shorter sides equals the square of the longest side (hypotenuse).

Question: Through the above exploration, what relationship have you found between the areas of the squares made with the sides of the right-angled triangle? What have you discovered about the quantitative relationship of the three sides of the right-angled triangle?

Through the exploration, you may have discovered the Pythagorean theorem, which is a fundamental relation in Euclidean geometry among the three sides of a right-angled triangle. This theorem can be a significant discovery in understanding the quantitative relationships and geometric properties of right-angled triangles, which is a foundational concept in mathematics.

Case Comparison Analysis Summary

The inception of a question is the starting point of thought, and the quality of question design directly impacts the effectiveness of teaching. Comparing the two teaching case studies, the importance of question design is undeniably evident. In Case Study 1, the teaching scenario of asking without answering or answering irrelevantly highlights a flaw in our teaching design. The design of questions in teaching strays from the students' cognitive level, making it difficult for students to initiate thinking. They are unsure of the direction in which to channel their thoughts, thus their thinking is not exercised. The process becomes painful for both students learning and teachers teaching. This not only dampens the students' interest in learning but also diminishes the teachers' enthusiasm in teaching, consequently affecting the teaching outcome.

On the other hand, in Case Study 2, through a series of well-structured questions, the teacher guides the students to explore and discover new knowledge. By employing the method of calculating areas, the teacher helps students inductively understand the quantitative relationship among the three sides of a right-angled triangle, transitioning from specific to general. This approach enables students to establish the connection from numbers to shapes, and from shapes back to numbers. Naturally, this method not only stimulates students' enthusiasm for learning but also makes teaching more relaxed and effective!

Concrete Embodiment of Cultivating Students' Mathematical Core Literacy in Secondary School Mathematics Classroom

Emphasizing the Cultivation of Divergent Thinking Skills to Tap Students' Potentials

Divergent thinking epitomizes the genesis of multifarious ideas, the proposition of novel concepts, and the identification and resolution of emergent problems predicated on established theorems, formulas, and known conditions. It is hallmarked by abundant associations, prowess in decomposition, amalgamation, extrapolation, generalization, and the adroit application of a variety of alternative methodologies. Divergent thinking encapsulates attributes such as fluency and flexibility. Fluency predominantly manifests in swift and adaptable thinking, adeptness in imagination, and the capacity to articulate numerous pivotal points and principles within a constrained timeframe (Xin & Shi, 2022). It facilitates both vertical and horizontal connections, culminating in a holistic comprehension. Flexibility, conversely, signifies the capability to formulate analogies, acclimate to varying circumstances, extricate from rigid thinking paradigms, swiftly alter thinking trajectories, pioneer new avenues, and exhibit uniqueness throughout the cognitive process.

Middle school scholars harbor the potential for innovative and distinctive cognitive endeavors. Educators should assiduously harness the merits of the psychological attributes inherent in middle school scholars, meticulously orchestrate pedagogical preparations, and accentuate practical efficacy. By executing these strategies, they can engender an ambiance conducive to divergent thinking, empowering scholars to traverse diverse perspectives, resolve quandaries creatively, and broaden their understanding beyond traditional confines. This initiative not only enriches the educational voyage but also fosters a milieu of innovation and critical analysis, which are indispensable skills for the scholars' academic and prospective ventures.

Cultivate students' ability to identify problems and improve their analytical skills

Through the guidance of teachers in classroom teaching, students can observe and analyze on their own, deriving unique insights and distinctive methods of thinking. This is what is referred to as being adept at identifying problems, which in turn facilitates the communication of the intrinsic connections among various types of knowledge, cultivating a form of innovative thinking (Ruoslahti, 2020). A good example of teaching the area study of trapezoids is the following.

Example: As shown in the Fig. 2, it is known that in pentagon ABCDE, AB∥ED, ∠A=∠B=90°. How many lines can divide this pentagon into areas of equal measure? How would you draw such lines?

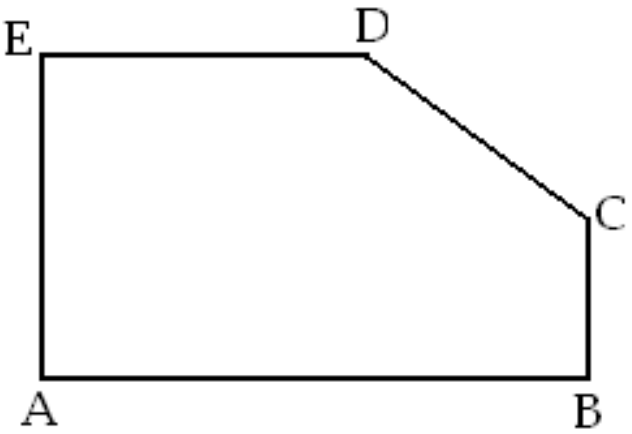

Fig. 2 Schematic diagram of a trapezoid in the example

Upon posing this question, students realized there could be countless lines. However, they were unsure how to draw these lines, so I provided them with some guidance: This is a somewhat irregular shape, but we can consider adding auxiliary lines, for instance, drawing a line parallel to AB through point C, which divides the pentagon into a rectangle and a trapezoid.

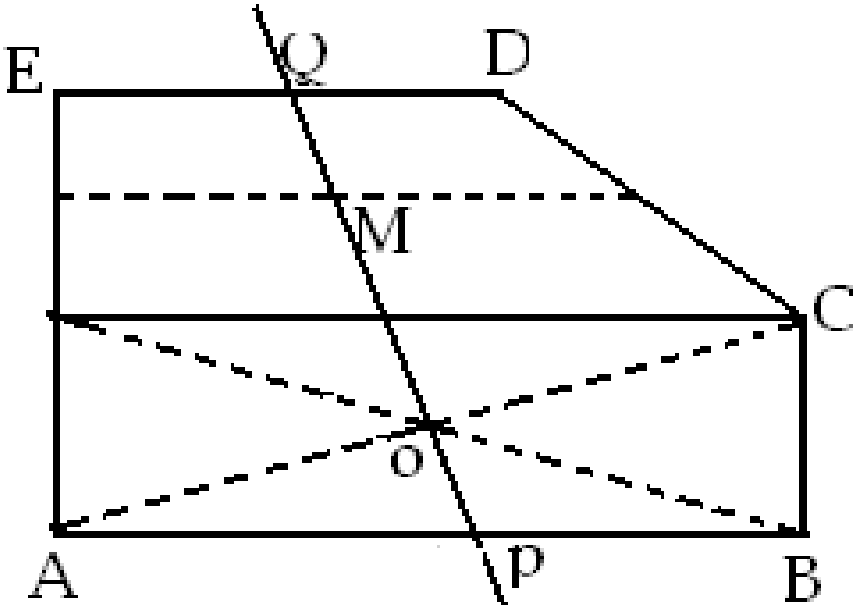

Fig. 3 Schematic diagram of trapezoidal cut in sample problem

Teacher: The question then transforms into discussing how to use a single line to equally divide the areas of the rectangle and the trapezoid. We are fairly familiar with dividing the area of a rectangle, so the question becomes how to equally divide the area of a trapezoid. Let's first look at the formula for the area of a trapezoid: $S=\frac{1}{2}(a+b)*h$*, And what does this part* $\frac{1}{2}(a+b)$ *in this formula equal?*

Students: The length of the median of the trapezoid.
Teacher: How then would you draw such a line?
Students: Just need to draw a line that bisects the median of the trapezoid, but it must intersect with the top and bottom bases.
Teacher: Clearly, the line connecting the center of the rectangle and the midpoint of the median of the trapezoid can divide the area of the pentagon equally. In fact, there can be countless such lines. Assume the line connecting the center of the rectangle and the midpoint of the median of the trapezoid intersects sides AB, ED at points P, Q, then any line passing through the midpoint of segment PQ and intersecting with AB, ED would meet the requirements of the question. Please try drawing it.

This interactive process not only engages students in active thinking and problem-solving but also encourages them to explore geometric relationships creatively, enhancing their understanding and innovative thinking skills in geometry.

Inspiring students' minds to develop a sense of creativity
The nurturing of cognitive competencies serves as a linchpin for the augmentation and flourishing of students' innovative faculties. Within the milieu of mathematics classroom instruction, educators should employ more tangible methodologies to foster and elevate students' inventive capabilities. The pedagogical journey ought to endeavor to ignite students' cognitive processes, aspire to shatter traditional paradigms, and shepherd students towards tackling quandaries from a myriad of vantage points. Paramount emphasis should be

accorded to cultivating students' innovative cognition by endorsing multiple resolutions to a singular problem, diverse contemplations on a singular theme, agility in problem-solving endeavors, and the acumen to extrapolate from a singular exemplar to broader precepts.

Conclusion

The nurturing of students' core competencies fundamentally hinges on fostering the core competencies inherent within each subject domain, with a particular emphasis on seamlessly integrating the efficacious development of core competencies within the pedagogical milieu of mathematics classrooms, ensuring its genuine implementation for every learner. Mathematics, being a cornerstone subject within the middle school curriculum, holds paramount significance. School education, especially within the confines of middle school classrooms, should underscore the cultivation of students' core mathematical competencies. To augment students' core competencies through classroom instruction, meticulous structuring of each lesson is imperative, entailing a rational delineation of class hours, optimal utilization of every instructional segment, and precise planning of classroom activities to align with the requisites of enhancing students' core mathematical competencies.

In the nascent stage of instructional activity design, specifically during the lesson preparation phase, the emphasis should gravitate towards guiding the trajectory towards core mathematical competencies; the cultivation of core competencies should germinate at the source. Concurrently, in the course of curriculum design, educators should incessantly center their focus on aligning with the ethos of mathematical culture, enabling students to transcend the drudgery and trepidation associated with mathematics learning, onerous academic tasks, and examination pressures. Instead, they should be accorded the opportunity to fully immerse in the joy of unraveling mathematical enigmas. Upon the discovery of the aesthetic allure of mathematics, students will invariably find delight in it, and an affinity for mathematics metamorphoses into the propelling force behind their academic voyage in the subject.

This study serves as a catalyst for secondary school educators, aiding in the enhancement of classroom design strategies by positing the transmission and cultivation of core mathematical literacy as the quintessence of teaching and learning endeavors. Additionally, this study propels the reform of the mathematics curriculum within the ambit of quality education as delineated by educational administration. Nonetheless, this study is not without limitations. While it proffers strategies to accentuate core mathematical literacy within secondary school mathematics classrooms, the assessment of their efficacy necessitates further validation. Consequently, future research endeavors will seek to bolster the justification of these strategies through a more robust empirical evidentiary framework.

This research substantially enriches the theoretical landscape of pedagogical methodologies in secondary school mathematics education. It meticulously examines the integration of core mathematical competencies into the curriculum, thereby not only aligning with contemporary educational reforms but also propelling the theoretical discourse on efficacious instructional practices. Our investigation elucidates the criticality of embedding core competencies within the educational paradigm, emphasizing the harmonization of teaching methodologies with the intrinsic ethos of mathematical culture. Theoretically, this study sheds light on novel pedagogical avenues, accentuating the infusion of enjoyment and aesthetic appreciation into mathematics education, thereby cultivating a deeper, more intrinsic student engagement with the subject.

In a contextual dimension, the study offers invaluable insights for practitioners in secondary education. The strategical framework proposed for the enhancement of classroom design, centering on the pivotal role of core mathematical literacy, resonates profoundly with the global imperative for quality education. This framework presents a versatile approach, adaptable across varied educational contexts, not only to augment mathematical competencies but also to equip learners with essential skills in critical analysis and problem-solving, pertinent to real-world applications. Moreover, by delineating its limitations and potential avenues for future inquiry, the study paves the way for subsequent empirical research, thereby contributing continually to the dynamic field of mathematics education research.

In summation, the theoretical and contextual contributions of this research are substantial, bridging pedagogical theory and practice. This bridge is pivotal in the effective cultivation of mathematical core literacy within the realm of secondary education, thereby enhancing both the quality and the relevance of mathematics teaching and learning.

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