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CRITICAL ANALYSIS OF SECONDARY MATHEMATICS CURRICULUM WITH SPECIAL REFERENCE TO MATHEMATICAL LITERACY

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Abstract:

In the 21st Century Education Scenario, Mathematical Literacy holds greater significance than traditional Mathematics because it emphasizes the application of Mathematical concepts in real-world problems. The National Education Policy (NEP) 2020 of India point out the significance of Mathematical Literacy as a crucial component of the educational framework. The investigator tries to find out the contextual problems for the meaningful understanding of Mathematical structures and procedures which are pivotal for mathematization. To enhance mathematical literacy among learners at secondary level, interlink among the mathematical structures are to be emphasized. For this purpose, the investigator analyzed 8 th Standard Mathematics textbook (Part I) followed by SCERT, Kerala based on the four contexts defined by PISA Framework 2021. The number of problem references in each context was converted into tabular form. The analysis of data reveals that the secondary Mathematics curriculum focused more on scientific contexts compared to personal, societal contexts; while the occupational context remains zero. Also it reveals that Eight Standard Part I Mathematics textbook should incorporate more balanced variety of problems including personal, societal, and occupational contexts alongside scientific ones would enrich students' learning experience, making Mathematical concepts more relevant and applicable to real-world situations

Keywords: Mathematical Literacy, Secondary Mathematics Curriculum

Introduction

Mathematics is a subject that closely related to one's everyday life. Therefore -Mathematics is a compulsory subject from primary classes onwards. According to the rapid changes occurred in science and technology; our society demands new skills and competencies for the success in the future. Mathematical Literacy is like a competency to solve problems encountered in the 21st century. PISA 2021(Programme for International Student Assessment) defined Mathematical Literacy as an "individual's capacity to identify and understand the role that Mathematics plays in the world, to make well-founded judgments and to use and engage with Mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen".

Mathematical Literacy includes making Mathematical deductions and applying Mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It aids in the identification and comprehension pf Mathematics' place in the world as well as the ability to make the kind of well-formed decisions and judgments that are necessary in daily living. The exercises used in PISA primarily focus on the daily practical applications of Mathematical knowledge in different real contexts. By contrast, Mathematics in which an explicit Mathematical problem is formulated without a real context, is unlikely to be the subject of PISA Mathematical exercises. An important aspect of Mathematical literacy is that Mathematics is used to solve a problem set in a context. The context is the aspect of an individual's world in which the problems are placed. For purposes of the PISA 2021 Mathematics framework, the four categories of the PISA 2012 framework have been retained and are used to inform assessment item development for PISA, the content, context and processes that are focused upon are given below.

Content areas:

- Quantity
- Space and Shape
- Change and Relationships
- Uncertainty and Data

Quantity: The notion of quantity may be the most pervasive and essential mathematical aspect of engaging with, and functioning in, our world. It incorporates the quantification of attributes of objects, relationships, situations and entities in the world, understanding various representations of those quantifications and judging interpretations and arguments based on quantity.

Space and Shape: Space and shape encompass a wide range of phenomena that are encountered everywhere in our visual and physical world: patterns, properties of objects, positions and orientations, representations of objects, decoding and encoding of visual information, navigation and dynamic interaction with real shapes as well as with representations, movement, displacement, and the ability to anticipate actions in space.

Change and Relationship: The natural and designed worlds display a multitude of temporary and permanent relationships among objects and circumstances, where changes occur within systems of interrelated objects or in circumstances where the elements influence one another.

Uncertainty and Data: In science, technology and everyday life, variation and its associated uncertainty is a given. It is a phenomenon at the heart of the theory of probability and statistics.

Contexts:

- Personal
- Occupational
- Societal
- Scientific

Personal: Problems classified in the personal context category focus on activities of one's self, one's family or one's peer group. The kinds of contexts that may be considered personal include (but are not limited to) those involving food preparation, shopping, games, personal health, personal transportation, recreation, sports, travel, personal scheduling and personal finance.

Occupational: Problems classified in the occupational context category are centered on the world of work. Items categorized as occupational may involve (but are not limited to) such things as measuring, costing, and ordering materials for building, payroll/accounting, quality control, design/architecture and job-oriented decision making either with or without appropriate technology.

Societal: Problems classified in the societal context category focus on one's community (whether local, national or global). They may involve (but are not limited to) such things as voting systems, public transport, government, public policies, demographics, advertising, health, entertainment, national statistics and economics.

Scientific: Problems classified in the scientific category relate to the application of Mathematics to the natural world and issues and topics related to science and technology. Particular contexts might include (but are not limited to) such areas as weather or climate, ecology, medicine, space science, genetics, measurement and the world of Mathematics itself.

Processes:

- Formulating situations Mathematically
- Employing Mathematical concepts, facts, procedures and reasoning
- Interpreting, applying and evaluating Mathematical outcomes

Formulating Situations Mathematically: The word formulate in the mathematical literacy definition refers to individuals being able to recognise and identify opportunities to use mathematics and then provide mathematical structure to a problem presented in some contextualised form.

Employing Mathematical Concepts, Facts, Procedures and Reasoning: The word employ in the mathematical literacy definition refers to individuals being able to apply mathematical concepts, facts, procedures, and reasoning to solve mathematically-formulated problems to obtain mathematical conclusions.

Interpreting, Applying and Evaluating Mathematical Outcomes: The word interpreting (and evaluate) used in the mathematical literacy definition focuses on the ability of individuals to reflect upon mathematical solutions, results or conclusions and interpret them in the context of the real-life problem that initiated the process.

The overall intention of PISA is to give a forward-looking assessment of the outcome of schooling by evaluating students' learning in relation to the challenge of real-life in different contexts.

Objective

To critically analyze Secondary School Mathematics Curriculum in terms of four dimensions under contexts defined by PISA 2021

Method used

The investigator analysed the 8 th standard Mathematics textbook followed by SCERT, Kerala. Content analysis was the method used by the investigator for this purpose. The Mathematics textbook has 10 chapters under three parts. The chapters are illustrated with wide range opportunities for the learners to dig out mathematical components in its pure and meaningful forms. Three chapters under Part I are analyzed by the investigator with a view to identify various contexts incorporated in the illustration part as well as practice problem part. The contexts are then categorized as Personal, Societal, Occupational and Scientific as defined by PISA 2021. The number of preferences in each contexts are tabulated and discussed in detail under the heading Analysis and Discussions.

Analysis and Discussions

Based on the Analysis of the chapter "**Equal Triangles**", number of problem preferences cited under each domain is represented in Table 1

Table 1: Number of problem references in each context in chapter "Equal Triangles"

Subtopics	Contexts			
	Personal	Occupational	Societal	Scientific
Sides and Angles				4
Two sides and an angle				5
One side and two angles				4
Isosceles triangle				6
Bisectors				4
Total				23

The chapter 'Equal Triangles' unravels the background against which we interpret PISA's Mathematical Literacy contexts called Personal, Societal, Occupational, and Scientific. It also shows how geometric ideas are used in actuality in diverse settings. The five subtopics - "Sides and angles," "Two sides and an angle," "One side and two angles," "Isosceles triangles" and "Bisectors" - present a variety of challenges now reserved for the scientific context. These context-based puzzles of science illustrate the varied scientific activities that are facilitated by geometrical understandings. This chapter did not delve into personal, societal, and occupational realms. By combining personal, social and professional aspects, the "Equal Triangles" section can provide a more comprehensive and practical understanding of geometry. This combination not only prepares students for a career in science, but also gives them important skills for daily life and many jobs, ultimately improving their math skills and overall engagement.

Based on the analysis of the chapter "**Equations**" number of problem preferences cited under each domain is represented in Table 2

Table 2: Number of problem preferences in each context in chapter 'Equations'

Subtopics	Contexts			
	Personal	Occupational	Societal	Scientific
Addition and Subtraction	4			2
Multiplication and Division			2	2
Different Changes			2	3
Algebraic Method			2	3
Different Problems			4	1
Total	4		10	11

Through analysing the chapter 'Equations' with unique attention on PISA Mathematical Framework 2021 reveals imbalance in problem contexts. In this chapter, personal context contains 4 problems, while societal and clinical contexts dominate with 10&11 problems respectively. But neglects the occupational context totally. Occupational contexts are critical for students to recognize the application of Mathematics in numerous careers and real-life situations. This loss of stability might also bring about students being much less prepared for real-international packages of Mathematics of their future professional lives.

Based on the analysis of the chapter "**Polygons**" number of problem preferences cited under each domain is represented in Table 3

Table 3: Number of problem preferences in each context in chapter 'Polygons'

Subtopics	Contexts			
	Personal	Occupational	Societal	Scientific
Shapes	-	-	-	-
Sum of angles				5
Outer angles				5
Unchanging sum				5
Regular polygon				9
Total				24

The chapter on polygons focuses mainly on scientific problems and ignores personal, social and professional problems. This skepticism leads to some academic shortcomings. The absence of personal questions makes Mathematics impossible for students' daily experience, thus reducing their involvement and interest in the subject. Likewise, the absence of social context problems means that students cannot connect geometric concepts to solve social problems. Additionally, failure to address occupational context problems is a complete oversight. It prevents students from understanding the importance of geometric patterns in many works, from architecture to construction, from graphic design to robotics.

Findings

Analysis of the Mathematics textbook (VIII) reveals that in the four contexts defined by PISA, the curriculum gives too much importance to the Scientific context. The predominance of scientific context problems ensures that students are well-versed in applying Mathematical identities to scientific scenarios, which is valuable for understanding theoretical and experimental sciences. Integrating scientific contexts into the curriculum exposes students to the interdisciplinary nature of Mathematics and its applications in various scientific fields. This interdisciplinary approach not only enriches student's understanding of Mathematics but also highlights the interconnectedness of different areas of knowledge, preparing them for future academic and professional endeavors in science, technology, engineering, and Mathematics (STEM) fields.

However, this strong orientation towards scientific contexts comes at the expense of adequately addressing personal and societal contexts, which contain only a few problems. This imbalance suggests that students may not be sufficiently exposed to Mathematical applications in everyday life scenarios, such as managing personal finances, making informed health decisions, or understanding social statistics, which are

crucial for developing practical Mathematical Literacy. The substantial number of personal context problems is also a positive aspect, as it helps students relate Mathematical concepts to their daily lives, enhancing engagement and practical understanding. The inclusion of societal context problems, though limited, allows students to see the relevance of Mathematics in addressing community and societal issues, fostering a sense of civic awareness and responsibility. Furthermore, the complete absence of problems in the occupational context is a significant oversight. This gap means that students are not being prepared to use Mathematics in professional settings, where skills such as data analysis, budgeting, and operational planning are essential. The lack of occupational context problems indicates a missed opportunity to equip students with the Mathematical competencies needed for future careers, thus limiting the textbook's effectiveness in fostering comprehensive, real-world Mathematical skills.

Integrating problem contexts that are personal, societal occupational and scientific into the Mathematics curriculum enriches the learning experience, fosters critical thinking and problem-solving skills, prepares students for future career opportunities, and cultivates a deeper understanding of the role of Mathematics in society and the broader world. Incorporating PISA contexts into the Mathematics for success in an increasingly interconnected world, and prepares them to meet the challenges of the 21st century.

Conclusion

Incorporating the contexts defined by Programme for International Student Assessment (PISA) Mathematical Literacy into the Mathematics is vital for several reasons. It helps students understand the relevance of Mathematical concepts in real-world scenarios, fostering deeper comprehension and application skills. It promotes critical thinking and problem- solving abilities by presenting Mathematical challenges within familiar contexts. PISA contexts can enhance student's global competitiveness by preparing them for international assessments and benchmarks. Hence integrating PISA contexts into the Mathematics curriculum enriches the learning experience and equips students with essential skills for success in the future.

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