

Mathematical Literacy as a Key Competency for Maritime Education: Systematic Review of Cadet Competencies

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ARTICLE INFO	ABSTRACT
<p>Article History</p> <p>Received : 24 Aug 2024</p> <p>Revised : 28 Aug 2024</p> <p>Accepted : 30 Aug 2024</p> <p>Available : 31 Aug 2024</p> <p>Online : 31 Aug 2024</p> <hr/> <p>Keywords:</p> <p>Mathematical Literacy Maritime Education Systematic Literature Review Cadet Competencies</p> <hr/> <p>Please cite this article APA style as: Novitasari, N., Agustina, E. N. S., Fachrudin, A. D., & Irfan, S. (2024). Mathematical Literacy as a Key Competency for Maritime Education: Systematic Literature Review of Cadet Competencies. <i>Vygotsky: Jurnal Pendidikan Matematika dan Matematika</i>, 6(2), pp. 131-140.</p>	<p>This study discusses the role of mathematical literacy as the main competency that cadets need to have in the field of maritime education. Through a systematic literature review (SLR), the mathematical literacy competencies needed by cadets in the maritime field are navigation, problem solving, use of modern technology, operational management, critical and logical thinking, and accurate data-based decision making. This systematic review provides an illustration of literacy mastery Mathematics not only supports cadets' understanding of basic maritime concepts, but also improves cadets' abilities in dealing with challenges or unexpected situations on board ships and while at anchor. Therefore, developing mathematical literacy must be a priority in cadet education and training programs to produce graduates who are competent and ready to face the complexity of the global maritime industry.</p>

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1. Introduction

Mathematical literacy is one of the key competencies in various fields, including the maritime sector (Velloo et al., 2015). In the era of globalization and industrial revolution 4.0, this ability is increasingly vital for professionals in the increasingly complex maritime industry. Maritime education has a vital role in preparing cadets to face challenges in the complex and dynamic maritime world. Therefore, maritime education as a forum for producing superior human resources in the maritime field requires special attention to develop the

mathematical literacy of cadets.

Cadets are said to have mathematical literacy skills in the era of the industrial revolution 4.0, if cadets are able to estimate, interpret information and even solve problems in various realistic ways so that they can provide reasons in numeracy, graphic and geometric situations and communicate using mathematics (Azmi et al., 2020). Therefore, mathematical literacy not only includes basic numeracy skills, but also involves the ability to analyze, reason, and communicate ideas effectively when identifying, formulating, and solving mathematical problems in various contexts. Mathematical literacy not only includes basic numeracy skills, but also involves the ability to analyze, reason and communicate ideas effectively when identifying, formulating and solving mathematical problems in various contexts (OECD, 2019).

Mathematical literacy not only involves understanding basic concepts, but also the ability to apply this knowledge in problem solving, decision making, and technological innovation (Jablonka, 2003). In the maritime context, mathematical literacy plays an important role in various aspects such as navigation, logistics management, weather and ocean current analysis, as well as the operation of modern maritime technology. These skills enable cadets to understand, interpret, and apply mathematical concepts in real situations, which is critical to safety and operational efficiency at sea. Good mathematical literacy also helps in making quick and accurate decisions in emergency conditions, reducing the risk of accidents and improving overall operational performance. Therefore, the urgency of study related to mathematical literacy in maritime education is becoming increasingly important along with the complexity of maritime operations and rapid technological developments.

The relationship between mathematical literacy and maritime education is very close, because mathematics is the core of various maritime activities. For example, ship navigation requires an understanding of geographic coordinates, distance and time calculations (Akbar, 2017), and the use of maps and navigation tools (Ningrum et al., 2015). In addition, engine operations and ship maintenance require accurate calculations to maintain efficiency and prevent damage. Mathematical skills are also important in logistics and resource management, such as fuel planning and inventory management. Cadets who have good mathematical literacy will be better prepared to face these challenges and contribute significantly to the success of ship operations.

The mathematical literacy competencies required by cadets include understanding basic mathematical concepts such as algebra, geometry and trigonometry, as well as the ability to apply them in a maritime context. They must also be able to use software and technology that relies on mathematics, such as ship management systems and electronic navigation tools. In addition, data analysis skills and interpretation of quantitative information are essential for making evidence-based decisions in operational situations. Cadets also need to develop logical, analytical, systematic, critical and creative thinking skills, as well as the ability to collaborate (Napitupulu, 2008; Syarif, 2016). This is the basis for effective problem solving in the field and is a characteristic of 21st century learning (Jaenudin et al., 2020).

Several studies have shown a positive correlation between the level of mathematical literacy and academic and professional performance in the maritime sector. For example, study reveals the importance of mastering

mathematical symbols and graphs in solving maritime problems (Veloo et al., 2015). Meanwhile, findings related to mathematical literacy abilities of 86% of cadets are in the proficient and proficient category in mathematics lectures (Lusiani & Suprianto, 2024). This shows that mathematical literacy is very important. However, although mathematical literacy is very important, there is still a gap between the needs of the maritime industry and the level of mathematical literacy of maritime education graduates. One of the study results identified that many cadets still experience difficulties in applying mathematical concepts in practical maritime contexts, especially in the operation of modern navigation technology (Purba, 2022).

The novelty of this study presents a new contribution by highlighting mathematical literacy as a fundamental competency in maritime education, which has not been discussed comprehensively in the maritime context. This is due to a gap, namely the lack of in-depth empirical research related to the implementation of mathematical literacy in maritime education, especially for cadets. Although much literature emphasizes the importance of mathematical literacy, very little examines how this literacy is applied practically in the context of maritime training and education.

Therefore, a comprehensive study is needed regarding the mathematical literacy competencies required by shipping cadets, as well as how to integrate the development of these competencies into the maritime education curriculum. This study aims to review the latest literature regarding the importance of key mathematical literacy competencies for shipping cadets, as well as formulate recommendations to improve the development of these competencies in maritime education.

2. Method

This study uses a systematic literature review (SLR) method. This study of articles using the SLR method uses Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Fachrudin & Juniati, 2023; Moher et al., 2009; Page et al., 2021). The steps used are as follows:

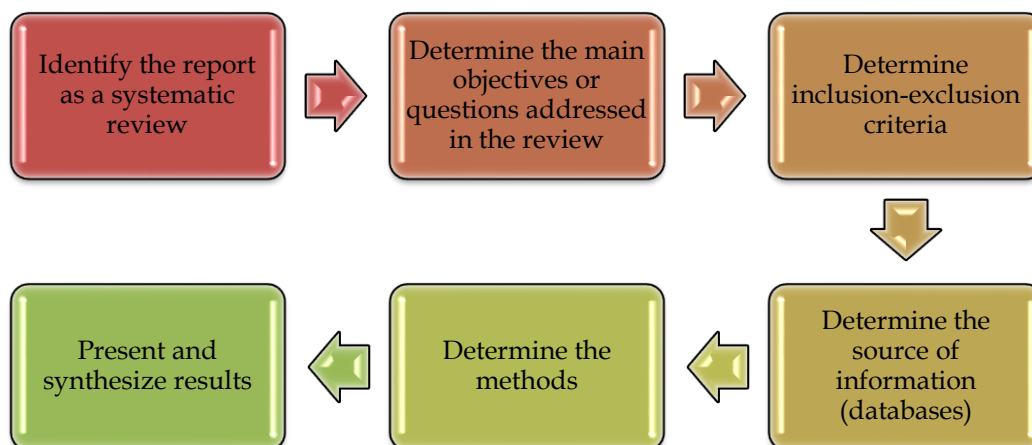


Figure 1. Flowchart of This Study

Based on Figure 1, this study procedure includes: a) identifying systematic reviews; b) determine the main aims and research questions addressed in this

review; c) determine inclusion and exclusion criteria for conducting such review; d) determine the source of information or database used to identify studies and the search date for each study article; e) determine the methods used to assess the risk of bias in the included studies; and f) present and synthesize the results.

This study conducted an extensive and comprehensive search for articles in digital databases using the "Publish or Perish" software to search for relevant information regarding the mathematical literacy competencies of maritime education cadets. Keywords used in searching for articles from journals and conferences based on the inclusion and exclusion criteria shown in Figure 2 are "mathematical literacy", "maritime education", and "cadet competency".

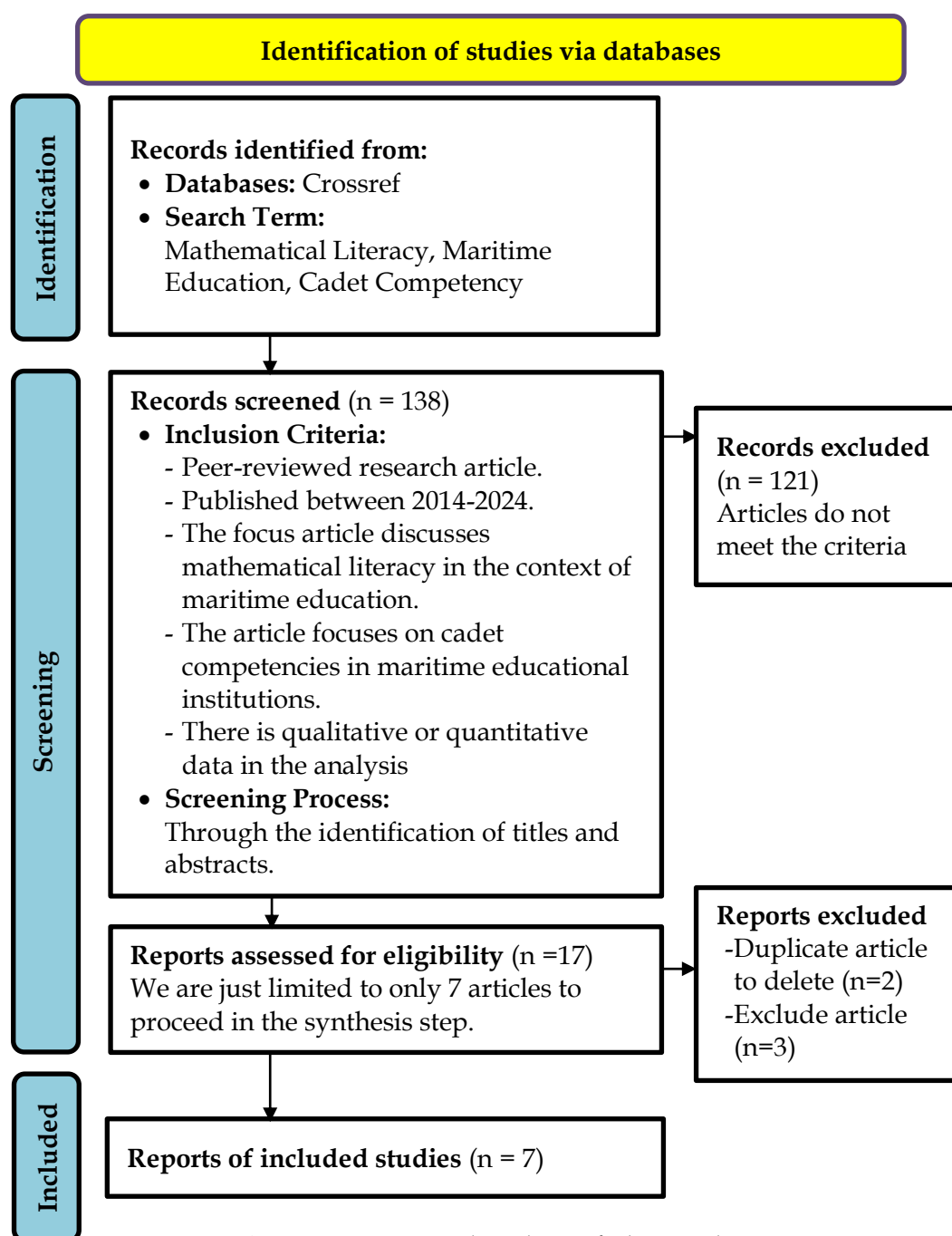


Figure 2. PRISMA Flowchart of This Study

The criteria for article publication years used in this SLR method are 2014 to 2024. The number of articles obtained in the initial stage was 138 with only 7 titles passing according to the stages of the systematic review process. There were 121 article titles excluded. This was because they did not meet the inclusion and exclusion criteria and limits that the researchers had determined. Some of the article findings that researchers then excluded were study that did not focus on students or cadets, prospective teachers, and discussions that did not focus on articles that did not provide a framework or indicators regarding mathematical literacy.

3. Results and Discussion

Based on the publication data that the researcher obtained, the following are the characteristics of the study that the researcher found. These findings include mathematical literacy at high school, vocational high school, and higher education levels. By examining various important roles related to mathematical literacy that can be associated with the field of maritime education, researchers carried out a synthesis stage. At the synthesis stage, the researcher only selected 7 articles for in-depth analysis which discussed the role of mathematical literacy as shown in Table 1 as follows.

Table 1. Synthesis Results of Research Articles on Mathematical Literacy

Author	Year	Title	Explanation
Tatjana Stanivuk, et al.	2017	Mathematics as a Science and Marine Activity Follow Each Other Throughout History (Stanivuk et al., 2017)	Mathematical literacy enhances maritime safety by aiding in navigation accuracy, cost optimization, and overall efficiency, ensuring safer voyages and operations in the shipping industry.
Chumachenko Mariia Mykolaivna	2023	Contemporary Methods of Mathematical training of Future Navigators (Mykolaivna, 2023)	Mathematical literacy is crucial for maritime education, ensuring future navigators can manage modern technical means, make quick decisions, and navigate in various situations, enhancing their professional competence.
Gabriel Senanu Akakpo	2016	The Role and Relevance of Mathematics in the Maritime Industry (Akakpo, 2016)	Mathematical literacy is crucial in Maritime Education due to its application in ship construction, space management, and port operations, enhancing problem-solving skills and industry performance.
S. P. M. Pillai, et al.	2017	Comparative Studies of Mathematical Literacy/ Education: A Literature Review (Pillai et al., 2017)	Mathematical Literacy plays a crucial role in Maritime Education by enabling learners to apply mathematical concepts in real-world maritime scenarios, enhancing their problem-solving skills and decision-making abilities.
Jinhyun Hong ,	2020	The Role of Numeracy	Mathematical literacy plays a

Author	Year	Title	Explanation
et al.		and Financial Literacy Skills in the Relationship between Information and Communication Technology use and Travel Behaviour (Hong et al., 2020)	crucial role in influencing ICT use and travel behavior, suggesting its significance as a key competency for various fields, including maritime education.
Anis Syafiqah Sohaimi, et al.	2022	Analysis of Mathematics Literacy Ability (Sohaimi et al., 2022)	Mathematical literacy is crucial for education. The study shows students struggle with math, highlighting the importance of enhancing mathematical abilities, including in maritime education for competency development.
Lusiani & Suprianto	2024	Kemampuan Literasi Matematis pada Taruna Ketatalaksanaan Pelayaran Niaga dalam Perkuliahan Matematika (Lusiani & Suprianto, 2024)	Mathematical literacy is very important for cadets because it not only supports cadets' academic success, but also prepares them for future challenges in cadets' maritime careers.

In the context of maritime education, mathematical literacy plays a very important role in forming cadet competencies who are ready to face global challenges in the maritime industry. Based on the results of the SLR analysis in Table 1, various mathematical literacy competencies required by cadets are identified, which include aspects of navigation, decision making, use of technology and operational management. The following is a further description of these competencies:

- a. **Mathematical Navigation Ability**
 Navigation at sea is one of the crucial aspects of maritime operations, and mathematical literacy plays a central role in this. Mathematical navigation skills involve the calculations necessary to determine a ship's position, speed, direction, and estimated travel time. One study result emphasizes that mathematics is used to ensure shipping safety through accurate and efficient navigation (Stanivuk et al., 2017). Cadets need to understand how to apply mathematical equations to determine optimal trajectories, avoid hazards, and set arrival times with high precision. Mistakes in calculations can have fatal consequences, so mathematical literacy is a competency that cannot be ignored in maritime education.
- b. **Problem Solving and Decision Making**
 The maritime industry often faces situations that demand quick and correct decisions, especially in unforeseen conditions such as bad weather or technical breakdowns. This highlights that cadets' ability to solve mathematics-based problems is very important to support decision making in the field (Mykolaivna, 2023; Pillai et al., 2017). This competency involves the application of mathematical concepts in practical contexts, such as determining the optimal load of a ship to maintain stability, planning fuel use, and evaluating risks during shipping operations. Thus, mathematical

literacy not only helps in better decision making but also in reducing risks and increasing the efficiency of maritime operations.

c. Use of Modern Navigation Technology

Technological developments in the field of maritime navigation require cadets to have strong mathematical literacy skills in operating and interpreting data from various modern navigation devices, such as GPS, radar and ship traffic management systems. Cadets must be able to use mathematics-based software to analyze data and make accurate predictions regarding conditions at sea (Hong et al., 2020; Mykolaivna, 2023). This technology not only helps in navigation but also in more efficient route planning and operational cost savings. Therefore, strong mathematical literacy enables cadets to maximize the benefits of modern navigation technology and improve the safety and efficiency of operations at sea.

d. Management and Optimization of Maritime Operations

Mathematical literacy also plays an important role in maritime operations management, which includes logistics planning, ship space management and port operations. The study results underline the importance of mathematics in making decisions regarding ship load distribution, storage space arrangement, and shipping route optimization to minimize costs and time (Akakpo, 2016; Pillai et al., 2017). This capability is critical to ensuring maritime operations run smoothly and efficiently. Cadets who have these competencies will be able to manage resources more effectively, ultimately contributing to the productivity and profitability of the maritime industry.

e. Critical and Logical Thinking

Critical and logical thinking supported by strong mathematical literacy is essential for cadets in identifying potential problems and developing effective strategies. Mathematical literacy is very important for cadets because it not only supports cadets' academic success, but also prepares cadets to face future challenges in maritime careers. Critical and logical thinking skills supported by mathematical literacy enable cadets to analyze complex situations and make the right decisions, which is key in facing various operational challenges in the maritime world (Lusiani & Suprianto, 2024).

f. Data Analysis and Data-Based Decision Making

In today's digital era, data plays an increasingly large role in decision making. Cadets need to have the ability to interpret numerical data which is then analyzed and use the results of the analysis to make data-based decisions that are accurate and relevant. The study results show that many cadets still face difficulties in understanding and applying mathematical concepts in the maritime context (Sohaimi et al., 2022). This emphasizes the need to strengthen mathematical literacy in marine education. Cadets who have good data analysis skills will be better able to respond to changing situations at sea, such as weather changes, fluctuations in fuel supplies, and ship traffic dynamics.

Based on the study results above, this study contributes to understanding the role of mathematical literacy for cadets in maritime education. However, as with every research, there are several advantages that add value and

disadvantages that need to be considered for further development. The following is a discussion of the advantages and disadvantages of this study which are shown in Table 2.

Table 2. Advantage and disadvantage of this study

Advantage	Disadvantage
<p>a. Strengthening Essential Competencies: This study emphasizes the importance of mathematical literacy as a fundamental competency in maritime education, so as to increase awareness of the importance of strengthening this aspect in the maritime education curriculum.</p> <p>b. Relevance to the Maritime Industry: By highlighting the relationship between mathematical literacy and the skills required in the maritime industry, this study provides a strong theoretical foundation to ensure that cadet education is relevant to real needs in the field.</p> <p>c. Systematic Approach: The use of the Systematic Literature Review (SLR) method allows this study to present comprehensive and structured findings, providing a clear picture of the existing literature and ensuring that the conclusions drawn are based on in-depth and critical analysis.</p> <p>d. Basis for Further Research: The results of this study can become a basis for further research that focuses on developing mathematical literacy in maritime education, thereby providing a further contribution to the development of cadet competencies.</p>	<p>a. Data Source Limitations: This study is only based on seven primary articles, which may not be enough to describe the entire context of mathematical literacy in maritime education. This could limit the generalizability of the findings.</p> <p>b. Limited Focus: This study focuses only on mathematical literacy without considering other literacies that are also important in maritime education, such as technological literacy or language literacy, which may also play an important role in cadet education.</p> <p>c. Limitations of Practical Implementation: Although this study offers strong theoretical insights, practical implementation of the results of this study in educational curricula may face challenges, such as resistance to curriculum change or resource limitations.</p> <p>d. Lack of Empirical Data: This study is based on a literature review and may be lacking in empirical data that could strengthen the findings or provide concrete evidence about the effectiveness of mathematical literacy in the context of maritime education.</p>

Therefore, it is hoped that understanding the advantages and disadvantages described above can become a reference for improving and developing research in the future, in order to strengthen and enrich the contribution of mathematical literacy to education and the maritime industry in a more comprehensive manner.

4. Conclusions

Based on the results and discussion through Systematic Literature Review (SLR) analysis, it can be concluded that mathematical literacy is a fundamental competency that must be possessed by every cadet in maritime education. This competency includes precise navigation skills, effective problem solving, use of sophisticated modern technology, efficient operational management, critical and logical thinking, and accurate data-based decision making. By mastering these

competencies, cadets will be better prepared to face challenges in the increasingly complex and dynamic maritime industry. Therefore, strengthening mathematical literacy in the maritime education curriculum is very necessary to ensure the readiness and success of cadets in their future careers. In addition, this study can be a basis for conducting further relevant study related to the development of mathematical literacy in the context of maritime education and sustainable professional.

Author Contributions

The first, second, and third authors designed the study concept and methodology. All authors performed an initial literature search and screening of articles. The first and third authors performed data extraction and study quality assessment. All authors contributed to the analysis and interpretation of the data. The first and second authors wrote initial drafts of the manuscript. All authors made critical revisions to the intellectual content. The second and third authors provided substantial input into the final writing. All authors have read and approved the final published version of the manuscript.

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Declaration of Competing Interest

The author declares that this study has no conflicts of interest reported in this article.

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