Enhancing Cooperative Learning in Mathematics Education through Sociomathematical Norms in the Era of Society 5.0

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Abstract **– The research analyzes the efforts to develop student cooperation profiles in mathematics subjects through sociomathematical norms. Society 5.0 is an era where humans collaborate with machines and technology. This is believed to diminish human relationships in society. This research applies a qualitative approach with literature studies described clearly, objectively, systematically, analytically, and critically to develop student cooperation profiles through sociomathematical norms. Research literature data was obtained from previous research articles published in reputable national and international journals. Data was collected using the Google Scholar search engine.**

The research results show that sociomathematical norms can foster student cooperation, giving rise to a spirit of collaboration. Sociomathematical norms can be developed using several learning approaches, e.g., contextual, problem-based, realistic mathematical, cooperative and collaborative learning models.

Keywords **– Cooperative learning, mathematics education, Pancasila student profile, sociomathematical norms, Society 5.0.**

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1. Introduction

The Pancasila student model represents Indonesian students as lifelong learners who possess global competence and exhibit behavior aligned with Pancasila values, characterized by six main attributes: faithfulness and devotion to God, noble character, international diversity, cooperation, independence, critical thinking, and creativity [17], [18], [19], [39], [47]. The Pancasila student profile encompasses the character and competencies developed through school-based activities, including school culture, intra-curricular learning, extracurricular programs, and projects that aim to strengthen the Pancasila student profile [3], [33], [45]. The Pancasila student profile plays a vital role in the Independent Learning Curriculum (Kurikulum Merdeka). This curriculum is driven by the goal of shaping students who embody the values of the Pancasila student model [43].

The third profile in the Pancasila student model is cooperation (gotong-royong). Gotong-royong embodies an appreciation for the spirit of collaboration, where individuals work together to solve common problems, foster communication and friendship, and assist those in need.

The sub-values of gotong-royong include respect, cooperation, inclusiveness, commitment to joint decisions, consensus deliberation, mutual assistance, solidarity, empathy, anti-discrimination, anti-violence, and volunteerism [12]. According to [49] gotong royong is founded on social interactions among individuals and groups, where assistance from others is necessary. Furthermore, [23] added that gotong royong fosters connections among various communities through shared activities and communal efforts. Its aim is to bolster the solidarity, relationships, and sense of unity among citizens. Gotong royong is a traditional Indonesian value, renowned for fostering strong community bonds and defining the nation's character [32]. It encapsulates the essence of unity and collaborative spirit among the citizens [54]. The spirit of gotong-royong has begun to diminish in Indonesian society. Therefore, character education with a spirit of gotong-royong will surely help Indonesia restore its ideology to its original purpose as the nation's founders. If the spirit of gotong-royong can be instilled in every Indonesian student, the results are Indonesian students who are tough, have a social spirit and do not give up easily under any circumstances based on the Pancasila character values in the third principle, Indonesian unity (Persatuan Indonesia), which is a manifestation of gotong-royong.

Technological developments in Society 5.0 affect all sectors of life [6], [46]. In Society 5.0, humans tend to collaborate with technology and machines, which can diminish the character of gotong-royong in society (especially in urban areas), including schools. According to [10] the practice of gotong-royong still exists in rural areas, whereas in big cities, it is rarely found and almost does not exist. Besides that, [20] also explained that in today's era, individualism is on the rise. This is primarily due to a lack of awareness of gotong royong values and a disparity between the knowledge of and the practice of gotong royong. Furthermore, [31] explained that based on the results of his research, the mutual cooperation behavior among students began to fade. The spirit of cooperation between students at school has decreased. They no longer work together to solve common problems and communication between them has decreased. As well as [40] also stated that, according to their research findings, the collaborative practices taking place in schools is still on a small scale, e.g., in tidying up the classroom, cleaning the rubbish bins, and gotong-royong in cleaning the school environment. Then, [15] also stated that the research findings indicate students frequently demonstrate a lack of solidarity when they have to work together with their friends. When asked to collaborate, they tend to act individually and are selective in choosing friends based on intelligence.

Developing character education in students is essential as the cultivation of national character represents the main goal of the country's education system. Besides that, [48] added that character education is the main objective in the learning process, which focuses on reinforcing student identity through the values of Pancasila. The Pancasila student profile represents a set of essential character traits that students are expected to develop, encompassing six key dimensions: 1) Faith in and devotion to God Almighty, and noble character; 2) Independence; 3) Collaboration; 4) Global diversity; 5) Critical thinking; and 6) Creativity. Instilling the character of gotong-royong for students is not only the responsibility of Pancasila and citizenship teachers. It is the responsibility of every teacher, including mathematics teachers. According to [43] the task of every teacher in school is to embody the values of gotong-royong for their students since one of the spirits of the Independent Learning Curriculum is to create the profile of Pancasila students' model through gotong-royong. In addition, [4] also added that teachers have an important role in instilling the spirit of mutual cooperation in students, both through role models and through joint activities inside and outside the classroom. Through this role, students are expected to be able to implement the value of mutual cooperation in everyday life. The success of education, in accordance with the goals of national education, does not only depend on the teacher's ability to convey knowledge, but also in shaping the character of students. Therefore, the development of the value of mutual cooperation is very necessary so that students can develop social attitudes and concern for the school and classroom environment. Then, how to develop the character of gotong-royong in mathematics learning? Can the character of gotong-royong only be formed through social interaction in the classrooms without any direct relationship with mathematics?

In social interactions, especially in group discussions, each individual requires a set of rules regarding behavior, called norms. In the context of mathematics learning, there are specific norms called sociomathematical norms, namely normative understandings that guide the learning process and variations in the pressure and effectiveness of mathematical thinking in building mathematical knowledge [24]. In general, social norms apply in everyday life, but in mathematics learning, these norms develop into sociomathematical norms through interactions between students and teachers. According to [11], these norms emerge from differences in perceptions, approaches, ways of thinking, arguments, expectations, and responsibilities in discussions, which are then harmonized through a negotiation process until a shared understanding is reached.

This interaction process is characterized by two important aspects, namely mathematical communication skills and social skills that students use to reach understanding and agreement. Sociomathematical norms are closely related to students' understanding of cooperation in solving mathematical problems. Therefore, mathematics teachers in the classroom need to implement learning models that encourage collaboration between students, to create an interactive learning atmosphere, and support the formation of a cooperative profile.

2. Methodology

The purpose of this research is to explore and thoroughly understand the theories and findings of previous research on the concept of the Pancasila student model profile, especially the value of cooperation and its development through mathematics education. For this purpose, the Systematic Literature Review (SLR) approach is used. The SLR approach helps reviewers map topics and theories that appear in the literature relevant to the research issue. The data used were collected from the Google Scholar database, especially research in Indonesia. Data collection was carried out in August-September 2023. The keywords applied during the literature search were "Sociomathematical Norm" and "Pancasila Student Profile". As a result of this process, 43 publications that were relevant to the research issue. The criteria for selecting articles in the SLR approach include: (1) The selected articles are specific to the topic of Sociomathematical norms and the profile of Pancasila students, (2) The articles are available on Google Scholar, (3) The full text of the article can be accessed and downloaded, (4) The articles selected include the necessary foundational data, (5) The selected articles must fully discuss Sociomathematical norms and the profile of Pancasila students. The data analysis used is the SLR analysis which highlights attempts to categorize topics and track developments concerning Sociomathematical norms and the profile of Pancasila students.

3. Results and Discussion

According to the results of the literature review, it was obtained that [5] analyzed the interplay between individuals, mathematics, and society that is formed in mathematics classes. Mathematics is a basic subject in the education curriculum. As the class level increases, mathematics learning becomes increasingly complex [41]. Learning mathematics encompasses not just individual cognitive processes but also collective actions within social interactions.

Furthermore, [52] found that social interaction in mathematics education is crucial for cognitive development, which progresses alongside group communication processes. Consequently, it is essential to conduct a comprehensive study on the significance of social interaction norms in mathematics education, referred to as sociomathematical norms [25]. Sociomathematical norms constitute the normative understandings that guide the learning process, highlighting the diversity and efficacy of mathematical thinking in the construction of mathematical knowledge [24].

The study of socio-mathematics concerns three things:

1) The relationship between individuals and mathematics (education) in society and vice versa;
2) The role of mathematics (education) within society and vice versa; and
3) Individuals learn, know, and teach in society. Arguments about student activities, differentiating norms into social, mathematical, and sociomathematical.

Social norms are rules and expectations regarding students' belief systems and their interactions with others in the classroom are essential for fostering a learning environment based on mutual respect and engagement [24]. Next, mathematical norms are rules and expectations related to students' belief systems, specifically about mathematics [24]. Then, sociomathematical norms are rules and expectations in community-based mathematics education that are relative to student belief systems, influencing how they interact with others in teaching and learning mathematics [24]. For example, explaining and justifying solutions, identifying and expressing agreement, understanding other people's explanations, expressing disagreement about ideas, and so on are social norms for discussions in which the whole class participates. Furthermore, [27] found that sociomathematical norms can be categorized into two types: a) Those related to the problem-solving process, and b) Those associated with participation in collaborative activities aimed at problem resolution. According to [50], students' understanding and awareness of how to communicate decision-making and thinking styles is an example of a social norm, and understanding what kind of argumentation is mathematically acceptable is an example of a sociomathematical norm.

Sociomathematical norms vary between traditionally structured classrooms and those following a reform-oriented approach. In conventional classrooms, students are expected to absorb the knowledge conveyed by the teacher. The teacher primarily functions as an explainer and clarifier, while students are tasked with interpreting and understanding the teacher's intended meaning.

Conversely, in reform-oriented classrooms, the collective responsibility of the classroom community involves explaining and justifying one's solutions, striving to comprehend others' reasoning, posing questions when something is not understood, and contesting arguments with which one disagrees. Despite this, reform-oriented mathematics classrooms are favored for their support of effective learning [29].

According to [25], [34], sociomathematical norms encompass several values: a) Collaboration; b) Discipline; c) Power; d) Freedom; e) Carefulness and persistence; f) Acceptance of different viewpoints; g) Mutual respect; and h) Understanding.

Sociomathematical norms refer to how students conceptualize mathematical understanding and position themselves within social contexts to co-construct mathematical meaning [16], [37]. Sociomathematical norms emerge from the development of mathematical learning and teaching experiences like self-confidence, self-efficacy, the valuation of attitudes, and the construction of individual arguments related to mathematics within the process of learning activities [7]. Furthermore, these norms can be cultivated through diverse interactive mathematics learning activities that promote active collaboration among individuals [30].

In its application, sociomathematical norms in the classroom are flexible, where teachers and students can become agents in forming their application to mathematics learning [13]. There are many interactions that teachers or students can have in mathematics learning, which form sociomathematical norms. Without realizing it, when mathematics learning is conducted in class in the form of activities, sociomathematical norms are used. Besides that, [29] found that students engaged in social and sociomathematical norms by initiating discussions, taking responsibility for proposing and providing answers, and accepting arguments that they deemed efficient. For example, when students provide their answers, the teacher can ask more challenging questions to explore the students' knowledge; even though some students only listen to the opinions of their friends, the teacher can ask how they got the answers. Then, [9] added that the sociomathematical norms in mathematics learning are: 1) Giving mathematics questions to students, 2) Offering students to complete mathematics problems on the whiteboard, 3) Offering students to ask questions about mathematics learning materials, and/or 4) Providing math exercises.

According to [14] sociomathematical norms can be developed by interacting with various classroom components with the teacher's mathematics learning activities. Sociomathematical norms are influenced by the contexts in the classroom.

For example, in the differential equations class, sociomathematical norms based on the interpretation of rates of change were enacted by the teacher.

These learning activities are developed through:

1) Presenting students with mathematical problems to be collaboratively solved in groups, beginning with an open-ended question;
2) Forming discussion groups based on the diversity of students in the class, including gender, intelligence, ethnicity, religion, habits, social classes, and circle of friends;
3) Variations in perceptions, approaches, ways of thinking, arguments, expectations, and responsibilities during discussions are harmonized through negotiation to reach a common understanding; and
4) Teachers take on the roles of facilitators, motivators, and coordinators, supporting students in linking mathematical concepts with their ways of thinking.

To promote the growth of sociomathematical norms, strategies include directing students' focus toward mathematical discourse, fostering comprehension of peers' ideas, and encouraging interaction and exploration among those ideas [53].

Consequently, while sociomathematical norms are essential to effective mathematics learning, there remains a perception among some that mathematics is purely an individual activity, with minimal influence from social interaction [16]. This is in line with [8] that skills are considered essential because there is a reasonably close relationship between students' social skills and a range of additional skills, including teamwork, peer interaction, group participation, forming new friendships, handling conflict, and learning to work together. According to [42], sociomathematical norms positively impact students' academic achievement and play a role in developing students' personalities. According to [38], sociomathematical norms positively correlate with students' mathematics learning achievement. The higher the sociomathematical norms, the higher the students' mathematics learning achievement. According to [24], sociomathematical norms need to be developed because mathematics is a means of logical, critical, and creative thinking with various characteristics so that it cannot be separated from human life in its various activities. Therefore, students need to be more active in the learning process in the classroom so that sociomathematical norm activities in mathematics learning have a positive impact on increasing students' academic achievement.

Sociomathematical norms can be developed using several learning approaches, such as contextual, problem-based, realistic mathematical, and cooperative learning models [16]. Several studies show that sociomathematical norms are applied in collaborative learning.

According to [26] on the subject of functions, and [28] on the subject of geometry, found that research subjects tended to emphasize aspects of familiarity or close friends in their social relationship patterns because it would be easier to accept and appreciate efforts made and create a sense of comfort in the learning process. The establishment of sociomathematical norms has a direct impact on mathematical agenda. An explicit connection between two broad mathematical fields analytical geometry and functions could have been established.

This connection would have fostered a discourse that enhances learners' abilities to interrelate mathematical concepts, thereby fostering *conceptual understanding* [1]. Moreover, this connection would require learners to apply their knowledge of straight lines and the determination of points on these lines. To accomplish this, engaging in reflective discussions about mathematical representations would be essential, thus encouraging *adaptive reasoning* [2]. The capacity to consider this approach, which may not be the anticipated one, reflects *strategic competence*. Another study by [27] on the subject of linear equations in two variables, found that research subjects tended to emphasize aspects of equal distribution of intelligence level abilities during group learning to make them more capable. Meanwhile [37], on the topic of algebraic forms, found that subjects who had positive beliefs about collaborative activities could not solve problems independently or always needed the help of friends or teachers.

Integration of these norms into mathematics learning activities is essential to building a cooperative profile (Pancasila Student Profile) through socio-mathematical norms. According to [22] explained that Pancasila as a state ideology is the result of a mutual agreement based on pluralism and not religious teaching that accommodates a majority group. Socio-mathematical norms, mathematics activity standards, and specific interactions in the classroom influence how students engage with mathematics content and each other [25]. These norms include values such as cooperation, respect, and caution, which are essential to fostering a cooperative learning environment [34].

A key strategy is implementing cooperative learning models such as Jigsaw or Think-Pair-Share. These methods encourage students to work together, share knowledge, and take responsibility for their group's learning [50].

Research supports that such models enhance student engagement and promote positive interdependence, central to developing a cooperative profile [36]. Creating a supportive learning environment involves arranging students in groups and facilitating discussions where they can collaborate on solving mathematical problems.

This approach aligns with sociomathematical norms emphasizing collaborative problem-solving and mutual support [38]. Through assessment methods that gauge both individual contributions and group collaboration, teachers emphasize the significance of these standards and motivate students to appreciate the value of collective effort [51].

Incorporating group reflections and feedback sessions allows students to understand and internalize the sociomathematical norms, helping them see the value of cooperation in achieving common goals [51].

Teachers play a critical role by modeling cooperative behavior and embedding these norms into the curriculum. This practice helps students develop not only mathematical skills but also a strong sense of cooperation and mutual respect, consistent with the Pancasila Student Profile's focus on character and social values [48]. In addition, [44] added that social capital also brings mutual benefits and showed that it does not apply to individualism. Relationships can be seen as a source of capital when actors can create obligations and expectations for each other.

Cooperation, or gotong-royong, is a form of cooperation between individuals and individuals and groups to work together in dealing with problems of mutual interest [31]. In mathematics, gotong-royong learning, or cooperative learning, involves five key elements: positive interdependence, individual accountability, face-to-face interaction among members, and group processing evaluation. Students are grouped heterogeneously according to their academic performance, ensuring that each group contains students with high, medium, and low mathematical skills [35]. The character of cooperation can change behavior, ways of thinking, and ways of acting, and the entire Indonesian nation will become better and have integrity [21]. Thus, it can be said that to foster a cooperation profile in students, teachers must design and implement learning through sociomathematical norms in collaborative and cooperative learning.

4. Conclusion

This research demonstrates that sociomathematical norms play a role in shaping students' collaborative skills in mathematics learning, particularly in the era of Society 5.0, which demands human-technology collaboration. A qualitative literature review indicates that these norms, when integrated through contextual, problem-based, realistic mathematics approaches, and cooperative-collaborative models, can enhance the effectiveness of students' social and academic interactions.

Consequently, the application of sociomathematical norms can be a crucial instrument for strengthening 21st-century social skills while supporting mathematics learning that adapts to technological advancements. This research provides conceptual contributions for teachers and curriculum developers, although it is limited to theoretical research without empirical field data.

Future studies are recommended to test the effectiveness of these norms through experimental or longitudinal research designs at various educational levels, as well as to examine variations in their implementation across different cultural and technological contexts.

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