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Bibliometric Analysis on the Topic of Difficulties in Subject of the Whole Numbers of 7 and 8 Grades Students

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The article analyses current problems in the field of mathematics among students of grades 7-8 in order to identify practical recommendations on the topic of integers in mathematics, based on the study of various areas of their teaching methods, integers. The structure and content of the educational process are considered. The main goal of the work is to identify scientific results on the difficulties of students in grades 7 and 8 on the topic of integers over the past 20 years (2001-2020) and analyze their volume, geographical distribution, types of publications, research areas, and authors who contributed. Integers were studied by many researchers and determined which areas of research were studied and which required more attention. In addition, an urgent problem in the work is to identify the difficulties of students in solving problems of increased complexity.

Keywords: mathematics teaching, difficulties in subject, bibliometric review

Introduction

Math is a subject that is taught from elementary school to college. It is also gradually becoming a subject that is taught from the real to the abstract. This must be learned, as it plays a very important role in solving the problems of everyday life. However, some students have some difficulties in understanding mathematics, so this leads to difficulties in solving mathematical problems (Kusuma & Retnawati, 2019). Difficulties are a symptom that occurs in students with low academic performance or below the established norm (Sugihartono, 2007). Difficulties can be interpreted as a state of the learning process marked by certain obstacles on the way to learning outcomes (Mulyadi, 2010). Therefore, it is necessary to analyze the difficulties that students face when solving mathematical problems.

Whole numbers are natural numbers, numbers opposite to them, and the number zero. The set of integers is denoted by the letter Z. The set of natural numbers N is a subset of integers. These values for assimilation of knowledge teaching and number are the most important aspects of the theory of numbers, from the beginning, because there is a relationship between the number in the system, and hence is not independent of the number of arithmetic definition and emphasize that. At the same time, from the very beginning, they reveal intuitions of integers as derivatives of addition, which also include a reference to the real world: the addition of the unit does

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not mean the addition of a sign in the strict sense of the word, but what the sign means. The use of intuition in determining a number could be objected to: Poincaré discussed this, but in the end suggested that intuition could not be discarded. In fact, he argued that "the main goal of mathematical education is to develop certain abilities of the mind, and intuition is not the least important of these abilities". "It is thanks to intuition that mathematics remains get in touch with the real world." Finally, this definition defines the number as one, two, three, etc. and places it in the field of signs (in words or numbers), signs of something being added to a number to get the next number. Numbers are signs that indicate quantities (Fursoy, 2020).

There is an interesting fact that the first words and symbols for numbers appeared about 5000 years ago in Sumer, on the territory of modern Iran. One of the first mathematical discoveries was, perhaps, the distribution of numbers into even and odd, which was associated with female and male names. An integer is one of the first concepts of mathematics that still excites curious people with amazing facts of interaction, similarity, and unpredictability. Is it not surprising that the property of an integer is the sum of all its divisors? Such numbers were known in ancient Greece and were called perfect integers.

The first ones are easily found:

$$496 = 1 + 2 + 4 + 8 + 16 + 31 + 62 + 124 + 248$$

$$8128 = 1 + 2 + 4 + 8 + 16 + 32 + 64 + 127 + 254 + 508 + 1016 + 2032 + 4064$$

A rational number can be defined as a number expressed by the a/b quotient of integers in which the denominator, b, is different from zero. According to the recent theory of numerical development, children who have not yet learned fractions often believe that the properties of integers are the same for all numbers. Indeed, one of the biggest difficulties in studying fractions arises from the use of properties of natural numbers to subtract rational numbers, which Ni and Zhou (2005) call "displacement of integers". This bias leads to difficulties in conceptualizing integers as decomposable units. From a mathematical point of view, there are fundamental differences between these two types of decimals. Firstly, the rational numbers represent a strictly ordered set, while the integers form a discrete set. There is decency of other rational numbers between two rational numbers, while there is no decency of another natural number between two natural numbers. Secondly, another property of rational numbers is the ability to write them from an infinite number of fractions. This corresponds to the concept of equivalent fractions. Thirdly, fraction symbols belong to types a/B. Students usually treat the numerator and denominator as two separate integers (Pitkettly & Hunting, 1996). They apply procedures that can only be used with integers (Nunez & Bryant, 1996). As a result, typical errors are observed in addition or subtraction problems (for example, $1/4 + 1/2 = 2/6$) and when comparing fractions (for example, $1/5 > 1/3$). In this case, the students' reasoning can be continued as follows: if the number is large, the value it represents is larger. But when we think about fractions, the larger denominator does not mean a larger value, but a smaller one. Another difficulty arises in multiplication problems. Multiplication of natural numbers always leads to a larger answer, but this does not apply to fractions.

An inappropriate generalization of knowledge about the natural numbers is even more sustainable, because in many ways it precedes the generalization of knowledge about the rational numbers. In order to overcome these errors, it seems that students need to carry out a conceptual reconstruction that integrates rational numbers as a new category of numbers with their own rules and functioning. Moreover, even in adults, knowledge about natural numbers often prevails in the processing of fractions.

In addition, the analysis of the articles in accordance with the given topic was carried out in this article. For example, in one of the articles we analyzed, the goal was to explain integers to children with disabilities and

achieve results accordingly. In another article, the goal was to form the best methods for explaining the topic of integers by primary school students. It should also be noted that in most of our articles, we compared the relationship of integers with fractional numbers, and found that understanding integers has a very high impact on understanding fractional numbers.

The concept of a number is one of the most important but complex mathematical concepts that children encounter in elementary school. An integer is one of the first concepts of mathematics. So far, integers are striking with striking facts about interaction, similarity, and unpredictability. For example, the property of an integer is that it is the sum of all its divisors ($6 = 1 + 2 + 3$ and $28 = 1 + 2 + 4 + 7 + 14$). Such numbers were known in ancient Greece and were called superlative integers (Afanasyev, 2011). Empirical studies conducted in different countries have revealed the difficulties of students. Students respond well to the use of algorithms, but they lag behind in understanding the concept of an integer and solving verbal and real-world problems (Retnawati, Arlinwibowo, & Sulistyaningsih, 2017).

There are many problems, the answer to which are only integers. They are called tasks in integers. These include: equations in integers (Diophantine equations); classical problems in integers (the problem of weighing, the problem of splitting a number, the problem of exchange, the problem of four squares), text plot problems in which the unknowns are integers, etc. Among these types of problems, the problems of equations solved in integers are of particular importance. This is one of the most interesting sections of number theory. The solution of equations in integers has been fully studied only for equations with two unknowns, but this is problematic for equations above the second degree with two or more unknowns.

When studying mathematics, the initial concept of the material serves as the basis for studying the following material. In mathematics, the source material will be a prerequisite for learning other material. Misunderstanding a concept leads to misunderstanding other concepts, and this misunderstanding makes it difficult for students to solve their tasks (Mardanova, 2011). Ways of solving difficulties can be seen in the works of foreign authors. In addition, the differentiation and application of other authors' methods leads to new results. The aim of the work is to synthesize the scientific methodological literature of foreign authors on the research topic.

Many foreign authors have conducted research on these issues. The following types of work are considered in this paper:

- Analysis of students' difficulties on oral tasks based on numbers;
- A set of non-negative integers;
- Mental operations and tasks for learning integers;
- Difficulties in solving complex problems on the topic integers;

In general, some bibliometric and systematic literature reviews fully disclose fractional numbers, while reviews of integers require addition. This paper considers an opportunity to fill this gap and provides a clear overview of scientific results in this area.

Difficulties in solving mathematical problems with integers are one of the main problems faced by students of grades 7-8. Because of these emerging problems, many authors have undertaken research in this area. We can find works dealing with various aspects of mathematics, such as integers, integer problems, or the influence of the concept of integers on the general understanding of mathematics. There are some bibliometric and systematic literature reviews dealing with these topics, but there does not seem to be a review dedicated to the topic of the difficulty of integers. We strive to fill this gap and provide an up-to-date overview of scientific results in this area. Table 1 lists previous literary and bibliometric surveys. These reviews used a systematic approach to data collection

and covered more than 20 publications. The "Year" column indicates the last year covered by this review, the "Dataset Size" column indicates the number of articles that were eventually analyzed, and the "Source" column lists the databases that were used. The table is sorted by the number of publications covered (the size of the dataset).

Table 1

Latest Bibliometric Studies of Problems on the Topic of Integers

Reference	Year	Page number	Source
Retnawati et al. (2017)	2021	4	Google Scholar
Meepracha (2015)	2006	5	Google Scholar
Gelfman, Kseneva, and Demidova (2011)	2009	18	Google Scholar
Mardjuki (1999)	2013	10	Google Scholar
Rasulov (2005)	2000	157	Google Scholar
Byrnes (1991)	2016	754	Google Scholar
Fursov (2020)	2018	84	Google Scholar

Taking into account the research objectives, we will focus on the following research questions:

- How have scientific results developed over the past 20 years on the topic "problems faced by integers"?
- What is the geographical location of the scientific results on the topic "problems faced by integers"?
- What methods for solving problems were proposed on the topic "difficulties arising on the topic of integers"?
- What are the results of the methods considered?

Research Method

Common bibliometric methods include analysis of publication frequency, authorship, geographical distribution of publications, the most prominent institutions and publication locations, as well as citation analysis, joint citation analysis, bibliographic comparison, co-author analysis, and joint word analysis (Cooney, Davis, & Henderson, 1975). The Google Scholar, Scopus, and Web of Science networks were used for this purpose. Scopus and Web of Science used the following phrases to get the results: mathematics, integers, mathematical calculations, number theory, difficulties in mathematics.

The procedure used for bibliometric review included the following steps:

- selecting data sources and defining search criteria
- refining results from all data sources
- answers to research questions
- data analysis and interpretation of results using bibliometric methods

Selecting Data Sources and Defining Search Criteria

The same criteria were used to search for articles in the Scopus and Web of Science data sources. The article title was chosen as the keyword because it is an integer. In addition, the following phrases were selected to match the articles on the topic: difficulties in mathematics, difficulties of students. The study covered the period from 2001 to 2021.

Refinement of Results and Data Set

As for step 4 of the search and filtering procedure, this subject area was deleted if all articles related to this subject area are outside the framework that is evaluated based on their titles. Subject areas are those specified in the classification used by Scopus and WoS. At the last stage, the remaining articles were examined for their

importance by examining their titles or annotations in case of ambiguous titles and in Google Scholar the number of results was. After studying the topics (and, if necessary, abstracts), with the exception of articles, conference documents, books or book chapters, articles that are not available in English, and articles that do not contain information about the publication, as a result, 93 relevant articles remained.

Table 2

Search and Filter Steps

Step	search criteria	Scopus result	Web of Science result
1	By document type: article	189	256
2	Language: English	179	248
3	Deletion of non-core areas	154	225
4	Deletion of articles whose content does not match	123	175

Review of Other Articles on the Topic Integers

The first article under consideration (Kusuma & Retnawati, 2019) provides for an oral approach to solving students' problems and research based on interviews. Analyzing students' difficulties in solving oral problems in activities involving integers is also a good way to improve the quality of students' learning outcomes in order to achieve maximum learning outcomes (Gödek, 2004). Students who have difficulties in solving oral problems are identified by analyzing incorrect answers and questions. Based on the results of this study, four causes of errors of students performing verbal calculations with specific numbers were identified. These are: students have difficulty understanding oral tasks , do not understand the concept of operations on integers, students do not have sufficient counting skills and inaccuracies. The first contributing factor is the difficulty of understanding verbal problems (Kusuma & Retnawati, 2019; Sugihartono, 2007; Mulyadi, 2010; Afanasyev, 2011; Retnawati et al., 2017; Mardanova, 2011).

The following article discusses the method of a graphical organizer for learning integers. This method is designed to develop students' ability to represent the theoretical essence of a topic, the problem being discussed, or a problem using a spreadsheet. When using it, students acquire the skills to clearly express the essence of the topic not in the form of a table, oral statement, or written text, but in the form of the main idea, the main concept, important aspects (Aksu, 2008).

The following research papers also use tasks that test both the main content elements and the ability to establish relationships between them, usually useful for diagnosing the systemic level of development of mental operations. As a conclusion, a task was proposed for experimental and control classes after studying the topic "integers".

Avchu and Durmaz (2011) taught students in grades 6 and 7 about the difficulties and mistakes they encounter when performing operations with "integers". As a result of the survey, it was noticed that students did not fully master the subject known as "integers". Students make repeated mistakes when comparing natural numbers, demonstrating their ability to distinguish between natural numbers and negative integers. They couldn't decide whether to put the number "zero" between positive integers or negative integers, and they ran into the problem of the "zero" sign. They avoided using the sign in operations called "multiplication" and "division", and even using it, they extrapolated incorrect results. When they tried to do "subtraction", they showed a tendency to subtract only the smaller number from the larger number.

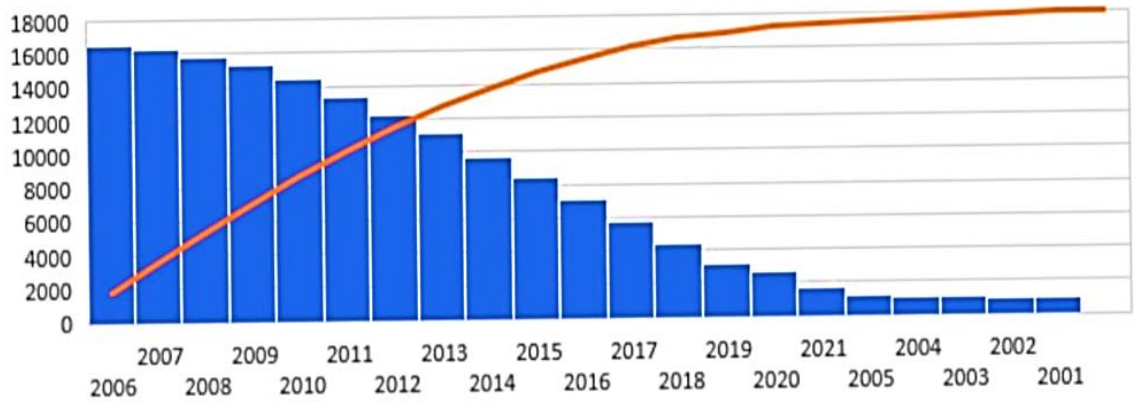

Figure 1. Publications in Google Scholar from 2001-2021.

Results

The final stage of the applied research procedure included data analysis and visualization of the results using bibliometric methods. The figure below clearly shows the number of publications in subsequent years. Between 2001 and 2006, the number of papers published annually was fairly stable. And since 2007, it has started to decline.

The problem of the second study is aimed at determining the geographical distribution of scientific results on the topic of integers. Figure 2 shows the most recommended countries in the dataset. The undisputed leader is the United States of America with more than 90 entries and a large disparity between all other countries, three of which—the UK, Germany, and Brazil—have about 20 entries each.

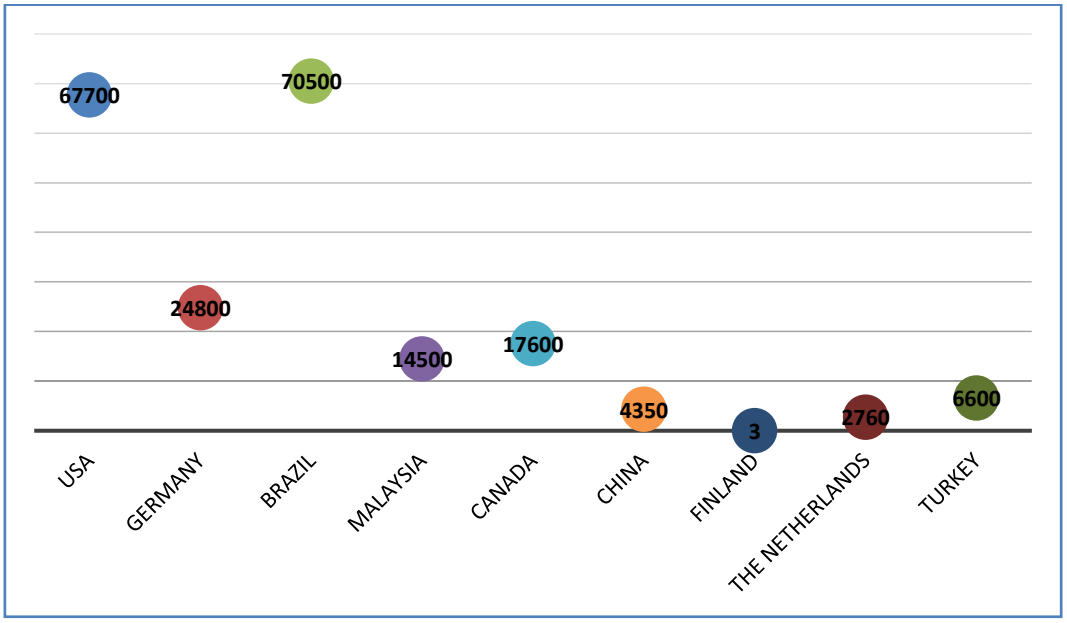

Figure 2. Geographical distribution of scientific results in Google Scholar.

The next research question concerns the author who has done the most productive research work on this topic. To determine this, the authors of the 10 articles discussed above are shown in the table below. This result was based on the scale of their work and research results.

Active Authors and Their Alliance in Various Studies

According to the pricing law, the minimum number of publications by major authors is calculated as $m \approx 0.749 \times\sqrt{N_{max}}$ where m refers to the number of articles and $N_{\max}$ refers to the number of publications by the most famous author. This means that when the number of articles published by an author exceeds m, that author is the main author in that field; and when the total number of articles published by main authors reaches 50% of all articles, the main group of authors was created in that field.

As can be seen from Table 3, $N_{\max}$ is 2, which, when added to the equation, gives $m \approx 1.05$, which means that authors with more than two publications are the main authors in this field. Analysis of the selected literature shows that between 2000 and 2021, four scientists published two or more articles, a total of eight publications, which is 4.7% of the selected literature (167 publications), which is less than 50%, indicating that the main group of authors in their research has not yet formed.

Table 3

Notable Authors in This Field and Their Publication

Publication	Authors
16	Alonso Diaz, Santiago
83	Cantlon, Jessica F.
503	Ramachandra, Nallur B.
643	Veerappa, Avinash M.

VOSviewer was used to analyze collaboration relationships of major authors, and the node type was set to get a visual map of the collaborative network of major authors in the field of research. As shown in the figure below, the lead authors only established poor relationships with a relatively Large Academic Group: there were no relationships between other authors, indicating that the research area was developing relatively poorly.

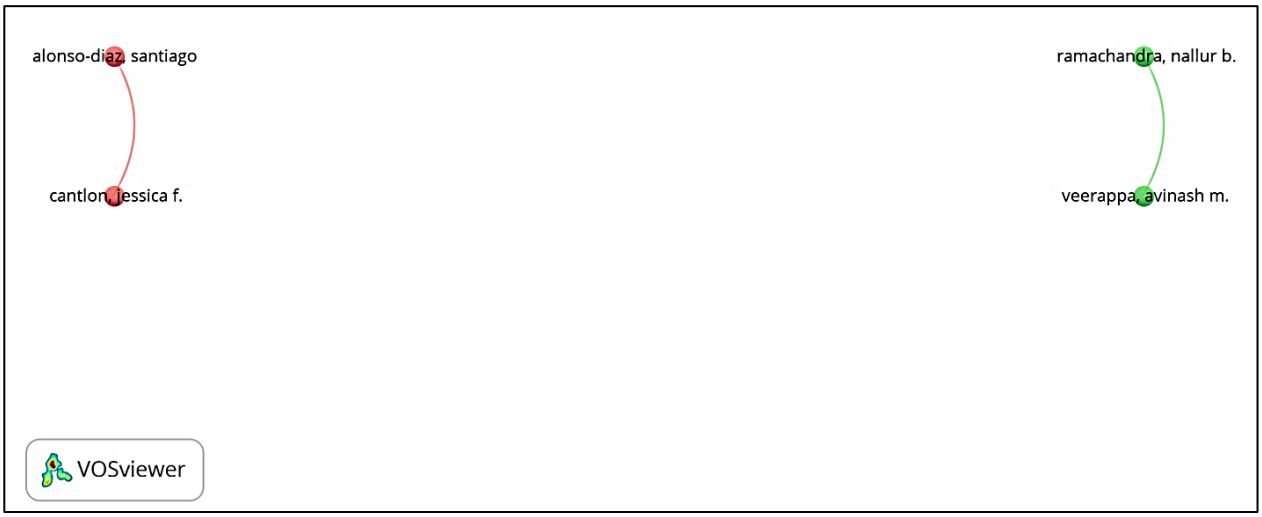

Figure 3. A visual look at the union of authors in the field of mathematical research.

Discussion

Using a bibliometric approach based on combining data from Scopus, Web of Science, VOSviewer, and Google Scholar, and using simple visualization tools, we were able to answer all the research questions raised.

As for the first research question, a constant number of publications are published annually from 2001, and in 2020, a smaller number of publications may be due to the fact that some publications are still in the process of indexing in the database. Also, in 2021, due to the pandemic, there is a high probability of significant growth, and many project organizations need to move from collaboration to a virtual organization, which in many cases affected the communication and interaction processes.

The second survey question stated that the United States ranked first, Brazil ranked second, and Germany ranked third.

The answer to the third question of the study shows that there are many methods to prevent problems on the topic of integers. The results of these studies showed the following conclusions. When working on verbal problems faced by students in grades 7-8, students' difficulties should not be reduced or even repeated. Based on the main factors, teachers should take a number of measures to reduce student errors in solving mathematical verbal problems, especially operations with integers.

On the fourth question of the study, the interpretation of the research results of the articles cited above shows the importance of providing and reproducing exercises for working with verbal problems to students, so that students can get used to understanding verbal problems and use numeracy skills. Analyzing students' difficulties in solving verbal mixed-count problems involving integers can be a good way to improve the quality of students' learning outcomes so that maximum learning outcomes can be achieved.

The information obtained from the research results is then used to improve the next learning process. Problems associated with students who have difficulty solving mathematical word problems, especially with numbers b, indicate errors in the learning process.

In addition, according to the results of VOSviewer, the topic that we are studying has not yet been fully studied. Although 167 publications were found in the Web of Science database, only four of them correspond to our topic. This result shows that our topic requires further development and in-depth study.

Conclusion

In this bibliometric review (2001-2020), we have tried to identify and analyze scientific results on the topic of difficulties in solving integers over the past 20 years (2001-2020). Research questions related to volume, geographical distribution, types of publications, areas and types of research, and authors who contributed.

In addition, the analysis of the articles was carried out in accordance with the topics given in this article. For example, in one of the articles we analyzed, the goal was to explain the exact figures to children with disabilities and draw appropriate conclusions. In another paper, the goal was to establish the best method for explaining a topic in integers by elementary school students. It should also be noted that in most of our articles we compared the relationship of integers and fractional numbers and found that understanding integers has a very big impact on understanding fractional numbers. As a result, similar articles on difficulties in learning integers published between 2001 and 2021 in 7th and 8th grades were examined. The aims and research approaches of the articles are discussed.

Using Google Scholar, we analyzed the topics and types of research. In addition, based on the results and discussions on the topics of difficulty in deducing integers, students' difficulties in solving mathematical problems and oral problems on integers were obvious: difficulties of oral accounting; students' difficulties in understanding the concept of fractions; students have less counting skills inaccuracy; Problems with the topic of integers between grades 7-8 mostly allow repeated errors when comparing numbers.

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