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HINDU MATHEMATICS IN MODERN ARITHMETIC: ASSESSING STUDENT AWARENESS AND UNDERSTANDING

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ABSTRACT

Hindu mathematics has made foundational contributions to the development of modern arithmetic, particularly through the introduction of the decimal number system and the concept of zero. Despite its historical significance, this study found that students' awareness and understanding of Hindu mathematics remain limited. This research investigates the role of Hindu mathematics in shaping modern arithmetic and examines students' knowledge of these contributions. The study employed a qualitative approach, combining a literature review to trace historical developments with student interviews to assess their conceptual understanding. Findings indicate a substantial gap in students' historical awareness, with most attributing the origins of modern arithmetic solely to Western and Arabic traditions. This gap is attributed to curriculum content that underrepresents non-Western mathematical heritage and a lack of accessible instructional resources. The study underscores the need to integrate Hindu mathematical contributions more explicitly into mathematics education to foster a more comprehensive and culturally inclusive understanding of the discipline's history.

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INTRODUCTION

Hindu mathematics has been instrumental in the development of modern arithmetic, especially due to its major contributions to the decimal number system and the invention of the concept of zero. Ancient Indian mathematicians first used this concept, which formed the basis for more efficient and organized calculations. The Indian decimal number system, based on position, allowed for easier and more precise calculations (Katz, 1993). In addition, this system contributed to the formation of more complex mathematical theories that are globally recognized (Plofker, 2009). Mathematical calculations can be performed more flexibly with the concept of zero, which was first described by Brahmagupta. This brought great advances in many fields of science (Ifrah, 2000). Therefore, the contribution of Hindu mathematics not only includes the basic concepts of arithmetic but also enables advances in many other disciplines.

The concept of zero and the decimal number system are very important in Hindu mathematics. Brahmagupta was the first to systematically establish zero as a number that could be used in calculations (Ifrah, 2000). Brahmagupta's contribution to the use of zero and his numerical system had a significant influence on the development of global mathematics (Plofker, 2009). The use of zero allows for more complex and organized calculations (Joseph, 2011). Zero is not only a number but also a concept, which provides structure in more complex mathematical calculations (Boyer, 1968). In this context, the emerging Indian decimal number system is considered a solid basis for more efficient calculations (Katz, 1993), significantly changing the way people use numbers.

Discoveries in Hindu mathematics, particularly in the use of the decimal and zero numeral systems, had a significant influence on modern arithmetic as we know it today. Before this system was used, number calculations were much more complicated, using numbers in alphabetical form or other inefficient systems (Joseph, 2011). Calculations became easier and faster with the decimal number system created by Indian mathematicians such as Brahmagupta. This system greatly helped the development of technology and science (Struik, 1987). In addition, the theories of algebra and calculus, two important fields in modern arithmetic, were greatly influenced by the concept of zero as a number separate from all others (Boyer, 1968). Therefore, these ideas were not only the basis for practical calculations but also contributed to many advances in mathematics that continue to develop today.

The application of this system allowed merchants and astronomers to make more

accurate measurements and transactions (Boyer, 2011). Moreover, the notion of zero and decimals is a major advance in mathematics, driving progress in many other fields (Struik, 1987). The decimal system and the concept of zero have changed the way we calculate, enabling major advances in many areas of science and technology (Dunham, 1990). The concept of zero and the decimal system are essential to contemporary technology, including computer systems (Ifrah, 2000). Therefore, these innovations remain relevant and are considered vital in the use of mathematics today, as well as in everyday life (Joseph, 2011).

In fact, the contribution of Hindu mathematics to the development of modern arithmetic has received less attention than the contributions of Greek and Arabic cultures. Despite its influence, the contribution of Hindu mathematics is often overlooked in mathematics courses, which focus more on Greek and Arabic traditions (Katz, 1993). Hindu mathematics is rarely highlighted in the teaching of the history of mathematics in educational institutions (Katz, 2007). Often, the Greek and Arabic cultural heritage is taught in schools, rather than the contributions of Hindu mathematicians to the development of arithmetic (Berggren, 2007). Unfortunately, many people do not realize that these concepts originated in ancient Hindu societies. Society often ignores the long history that shaped modern mathematical knowledge (Schaffer, 1999).

It is important to broaden our understanding of different mathematical traditions so that we can appreciate the intellectual diversity that exists (Hacking, 2000). The use of the decimal system and the use of zeros were major innovations that drove the progress of mathematics and other sciences (Berggren, 2007). The discovery of the concept of zero and the decimal number system were important achievements that shaped modern arithmetic. The decimal number system and the concept of zero have become an important part of mathematics education worldwide, helping in areas such as calculus and number theory. The journey of mathematical concepts from India to the Middle East, and finally to Europe, was crucial in shaping modern arithmetic (Pingree, 1981).

Studies show how important Hindu mathematics was to the development of arithmetic and algebra. Indian geometric methods also helped in the understanding and application of the concepts of decimal numbers and zero (Seidenberg, 1978). The intellectual contributions of India have been interwoven with the development of global science through the spread of mathematical ideas around the world (Seidenberg, 1978). It is important to recognize the contributions of different cultures in the history of mathematics (Sarton, 1927). By

understanding the origins of these concepts, students can appreciate the diversity of cultures that contributed to modern science.

To gain a broader understanding of science, it is important that we understand and respect the intellectual heritage of different cultures. The history of science cannot be separated from the cultural context in which it developed (Kline, 1980). Students can learn more about the contributions of Hindu mathematics, which can help them understand that science is the result of many complex cultural relationships. Understanding diverse mathematical traditions allows us to appreciate the contributions of different civilizations (Katz, 2007). An appreciation of the diverse history of science can enrich our understanding of human intellectual development (Hacking, 2000).

This study aims to raise students' awareness of the important role of Hindu mathematics in establishing the foundations of modern arithmetic. Knowledge of the history of mathematics is essential for students to understand how scientific thought develops and the cultural interactions that shape contemporary science (Katz, 1993). Understanding the global history of mathematics is essential for students to have a broader perspective on the evolution of science (Plofker, 2009). Understanding the history of mathematics provides students with a deeper context of how scientific concepts have evolved, as well as their impact on society (Seidenberg, 1967). Interactions between different scientific traditions have greatly influenced the development of mathematics, suggesting that cross-cultural understanding is essential for recognizing broader contributions to science (Van der Waerden, 1985).

Especially in terms of basic concepts such as the decimal number system and the number zero, this research emphasizes the important role of Hindu mathematics in the development of modern mathematics. This research highlights the importance of introducing and promoting Indian mathematicians such as Aryabhata and Bhaskara. This differs from other research, such as that conducted by Katz in 2009, which focuses more on western mathematical tradition. Thus, the aim of this research is to provide a more balanced perspective on the history of mathematics, which is often neglected in the educational curriculum.

METHOD

This study uses literature analysis and qualitative methods, centered on direct interview techniques to collect data. Literature analysis includes searching, collecting, and assessing relevant sources. The results are combined to formulate arguments and establish a context for

further research (Booth, 2008). A variety of relevant sources regarding the history of Hindu mathematics, including classical works, are then analyzed. The researcher must set the research question, conduct a literature search, analyze and assess the quality of the research, and compile a summary that brings together the main findings to conduct an effective literature analysis (Petticrew, 2006).The interview technique was chosen because it allowed the researcher to gain a better understanding of the students' views on Hindu mathematics and its role in the development of modern arithmetic.

This research uses a qualitative approach with direct interviews as the data collection method. This method was chosen because it can provide a deeper understanding of the role of Hindu mathematics in the development of modern arithmetic. Six randomly selected mathematics students from Universitas Negeri Padang were interviewed. The choice of participants was based on their interest and background in mathematics. The purpose of the interviews was to determine the extent to which the students understood the contribution of Hindu mathematics to the decimal number system and the concept of zero, as well as its impact on the development of modern arithmetic.

Some of the questions asked during the interviews aimed to enhance the participants' understanding of Hindu mathematics. These include:

1. Do you know where the concept of zero comes from?
2. Do you know that Hindu math introduced the use of decimal numbers?
3. Do you know of any mathematical ideas that originated from Hindu mathematics?
4. Have you ever heard of Hindu mathematics?

The purpose of these questions is to evaluate the basic knowledge students have about the role of Hindu mathematics in the advancement of modern arithmetic.

The analysis process begins with the transcription of the interviews, which converts the interview recordings into written text. The data collected from the interviews will be thematically analyzed. After that, the researcher will identify the main themes from the participants' responses, especially regarding what they think about the contribution of Hindu mathematics to the development of modern arithmetic. The results of these interviews will then be compared with the findings from the literature analysis to enhance the understanding of the important role of Hindu mathematics in the historical development of modern arithmetic.

This research aims to provide a deeper insight into college students' knowledge of Hindu

mathematics and the factors that influence their understanding of the role of Hindu mathematics in the development of modern arithmetic. In addition, this research also aims to provide a more balanced understanding of the history of mathematics, which is often overlooked in the educational curriculum.

RESULT AND DISCUSSION

This section presents the results of the study and discusses their implications. First, it explores the development of the concept of zero and decimal numbers in Hindu mathematics and examines how these contributions have shaped the evolution of modern arithmetic. Then, it summarizes the findings from interviews conducted with students to assess their awareness and understanding of Hindu mathematics. Finally, it discusses the reasons why the contributions of Hindu mathematics are less recognized in contemporary education and mathematical discourse.

The Development of the Concept of Zero and Decimal Numbers in Hindu Mathematics and Its Impact on Modern Arithmetic

One of the most famous mathematicians of 7th-century India, Brahmagupta, is known as the creator of algebra and arithmetic. He was born in Ujjain, which at the time was a center of science and astronomy. In his famous work, *Brahmasphutasiddhanta*, written in 628 AD, Brahmagupta established the basic rules for mathematical operations involving zero and introduced zero as an independent number. This discovery was essential to meeting the real needs of society at the time, which required better calculation techniques for trade and astronomy. Brahmagupta made zero an integral part of the number system, thus paving the way for more complex calculations (Ifrah, 2000). Therefore, Brahmagupta's contribution to the concept of zero and the decimal number system significantly advanced mathematics.

Hindu mathematics, particularly the invention of the concept of zero and the decimal number system, played a crucial role in forming the basis of modern arithmetic. The concept of zero, established by Brahmagupta, allowed for more complex calculations and the delineation of larger numbers. By functioning within a positional number system, zero became an important foundation for the advancement of modern arithmetic, as seen in Figure 1.

Hindi/Devanagari Numbers हिंदी/देवनागरी संख्या

०	0	Shunya	शून्य्
१	1	Ek	एक
२	2	Do	दो
३	3	Teen	तीन
४	4	Chaar	चार
५	5	Paanch	पांच
६	6	Che	छे
७	7	Saat	सात
८	8	Aath	आठ
९	9	Nau	नौ

Figure 1. Indian Number System (Source: *https://apkpure.com*)

Several other Hindu mathematicians also contributed greatly to the development of Indian mathematics before Brahmagupta. Aryabhata, a 5th-century mathematician, used the empty symbol in his number system but had not yet introduced it as an independent number. Additionally, the concept of decimal numbers had developed long ago in the Brahmi notation system, which was the forerunner of the Hindu-Arabic number system. Therefore, Brahmagupta's thought did not emerge in isolation, but was an accumulation of ideas that had been developing over time.

Hindu mathematics also produced the decimal number system, which Brahmagupta used in the 7th century to perform various mathematical operations such as addition, subtraction, and division. The decimal system was later improved by Bhaskaracharya II in the 12th century. The Hindu-Indian decimal number system became the basis for many arithmetical innovations that were adopted by the Arab world and later introduced to Europe (Joseph, 2011). This decimal system enabled more efficient calculations of large numbers, especially in trade and astronomy.

After developing in India, the Arabs began using the Hindu number system, most notably through the work of Al-Khwarizmi in the 9th century. Al-Khwarizmi explained this number system and spread it to the Islamic world, where it flourished. The Hindu-Arabic number system eventually became known in Europe through trade networks and the translation of manuscripts into Latin. European countries continued to use the Roman numeral system, which was less effective in arithmetic operations, especially for multiplication and division, before the Hindu-Arabic system was widely adopted. Consequently, the adoption of the Hindu-Arabic number system in Europe was a major step towards the mathematical revolution in the west.

The relationship between the concept of zero and the decimal system is crucial in modern

arithmetic. In modern arithmetic, a positional number system is used, where the value of a number depends on the position of its digits in a set of numbers. Arab mathematician Al-Khwarizmi took the Hindu number system and spread it to the Islamic world, impacting the advancement of mathematics in Europe (Katz, 2009). Al-Khwarizmi's works, based on the Hindu number system, began to be distributed in Europe in the ninth century through Latin translations. Ultimately, the Hindu-Arabic number system replaced the Roman numeral system, which was more difficult to use in arithmetic operations.

The concept of zero and the decimal system also enabled various advancements in modern arithmetic. One of the most obvious examples is multiplication and division algorithms, which are much more efficient than previous methods. For example, the column multiplication method used in schools today relies heavily on the decimal number system and uses zeros as place fillers. In addition, this system allows for more accurate interest and tax calculations in the banking and finance industries. Therefore, ideas about the decimal number system and zero influenced both mathematical theory and everyday life.

Many aspects of modern life are influenced by the contribution of Hindu mathematics in the discovery of zero and the decimal number system. Today's world cannot develop without these concepts and systems. The transfer of the idea of zero and the decimal system from India to the West was a landmark event in the history of mathematics, connecting ancient times with modern times (Pingree, 1981). Fields such as computers, physics, economics, and basic arithmetic operations rely on these systems.

The concept of zero in Hindu mathematics, apart from being used as a practical tool in calculations, is also influenced by Indian philosophy. According to some schools of Indian philosophy, zero or *shunya* symbolizes unity and emptiness with the universe and has a deeper meaning than just a number. This idea probably contributed to the way Hindu mathematicians developed the concept of zero as a number that has value and an important role in the number system. Consequently, in India, the development of zero was driven by deep philosophical concepts as well as practical needs for trade and astronomy.

Further research should explore how these findings continue to contribute to technological and scientific advances. For example, the decimal system and the use of zero enabled advances in calculus, which is used in many scientific and technical applications. The arithmetic techniques taught in modern schools are derived from the Hindu decimal number

system (Plofker, 2009), showing that Hindu mathematical traditions remain relevant in the modern era.

Although much has been written about the contributions of Brahmagupta and other Hindu mathematicians to the concept of zero and the decimal number system, some important aspects remain unknown. One of these is the cultural and philosophical influences that affected the development of mathematics in India. Mathematics in India not only served as a practical tool but was also a reflection of a deep philosophical way of thinking (Joseph, 2011). Further research is also needed to gain a better understanding of how Indian and Arab mathematicians interacted with each other, especially in relation to the exchange of knowledge that took place during the Islamic Golden Age. The transformation of mathematical concepts from the Hindu tradition into the Arab context had a significant impact on the development of European mathematics (Plofker, 2009). By delving deeper into these aspects, we can gain a more comprehensive understanding of the legacy of Hindu mathematics and how it has impacted modern science and technology.

Results and Summary of Interviews

It is important to understand that these interviews were conducted to find out how students understood the contribution of Hindu mathematics to the development of modern arithmetic. Several questions were asked to determine the extent to which students understood the concept. Table 1 shows the results of the interviews, providing a clearer picture of their understanding.

Table 1. Interview Results

Question	Student	Answer	Knowledge Level
1. Do you know where the concept of zero comes from?	Student 1	Yes, I know, the concept of zero was first coined by a Muslim scientist, Al Khawarizmi.	High
	Student 2	I know, from the Islamic mathematician, Al Khawarizmi.	High
	Student 3	I don't know.	Low
	Student 4	As far as I know, the concept of zero was discovered by a Muslim mathematician, Al Khawarizmi.	High
	Student 5	I don't know.	Low
	Student 6	I don't know about the origin of the concept of zero.	Low
2. Do you know that Hindu math started the use of decimal numbers?	Student 1	I just found out about it.	Medium
	Student 2	Didn't know.	Low
	Student 3	I know.	
	Student 4	No, I don't.	Low
	Student 5	I know.	
	Student 6	I did't know that the concept of decimals appeared in Hindu mathematics.	Low
3. Do you know of any mathematical ideas that come from Hindu mathematics?	Student 1	Since I know Ramanujan, the only Hindu math concept I know is Ramanujan summation.	Medium
	Student 2	I don't know.	Low
	Student 3	I don't know.	Low
	Student 4	No.	Low

	Student 5	The concept of zero, decimalization system, and arithmetic.	High
	Student 6	I don't know.	Low
4. Have you ever heard of Hindu math?	Student 1	I have but I am not familiar with Hindu mathematics, but I know a Hindu mathematician, Ramanujan.	Medium
	Student 2	Never.	Low
	Student 3	Yes.	Medium
	Student 4	I have, but I don't know much about it.	Medium
	Student 5	Yes	Medium
	Student 6	Once, if I'm not mistaken, Hindu math produced ten numbers that are used today	High

The interviews with six mathematics students showed that there were differences in their understanding of how the concept of zero originated. Three students (1, 2, and 4) attributed the concept of zero to the Muslim scientist Al-Khwarizmi, indicating their understanding of how Islamic traditions influenced the development of the number system and the concept of zero. The other three students (3, 5, and 6) did not know the origin of the concept of zero, indicating that they did not understand the topic. It is crucial to understand what the concept of zero is because it forms the basis of the decimal number system used in modern mathematics. Additionally, although Al-Khwarizmi helped spread mathematical knowledge, it is important to remember that the concept of zero first appeared in Indian society before it eventually made its way to the Islamic world.

Students 1, 3, and 5 showed sufficient understanding of the origins of the decimal number system created in the Hindu mathematical tradition, but students 2, 4, and 6 did not know about it, indicating that they did not understand the historical development of this mathematical concept. These results suggest that the curriculum should place greater emphasis on learning about the significant contributions of Hindu mathematics to the decimal number system used globally today.

Most students did not seem to fully understand the various mathematical concepts derived from the Hindu tradition. For example, student 1 said that the only Hindu math concept they knew was the "Summation of Ramanujan," while students 2, 3, 4, and 6 could not provide relevant answers regarding Hindu mathematical concepts. Only student 5 could mention important concepts such as arithmetic, the decimal system, and zero, which are major contributions of the Hindu mathematical tradition. These results suggest that students lack an understanding of Hindu mathematical heritage, which should be better introduced in the curriculum to provide a more comprehensive insight into such contributions to the development of mathematics globally.

In terms of familiarity, Student 2 did not know much about Hindu mathematics, while Student 6 understood it better, even mentioning how Hindu mathematics contributed to the creation of the ten numbers used today. Students 1, 3, 4, and 5 showed moderate knowledge, with some mentioning Ramanujan but not identifying other concepts from Hindu mathematics. These findings suggest that students' understanding of Hindu mathematics differs, possibly because the curriculum does not sufficiently highlight the significant contributions of this tradition to the development of mathematics worldwide.

Overall, the interviews revealed that although some students were aware of the contributions of Hindu mathematics, their understanding of the importance of these concepts in the context of modern arithmetic was lacking. This suggests that the history and contributions of Hindu mathematics need to be better integrated into the educational curriculum to increase students' awareness and understanding of mathematics education.

Reasons Hindu Mathematics is Less Recognized

Formal mathematics education often ignores Hindu mathematics, which made major contributions to the development of modern mathematics. Education systems typically focus more on Western and Arabic mathematical traditions, while contributions from other cultures, including India, are often overlooked (Katz, 2009). This is the primary reason that students do not know how mathematics originated.

Additionally, one of the main factors leading to the lesser recognition of their contributions is the lack of translation of Hindu mathematical texts. The works of Hindu mathematicians such as Brahmagupta, Bhaskara I, and others are still written in Sanskrit or other ancient languages that are difficult for modern readers to access. In contrast, the works of Western and Arabic mathematicians are more widely translated into the world’s major languages, hindering the wide dissemination of their ideas (Pingree, 1981). Our understanding of the contributions of Hindu mathematics could be significantly improved if more efforts were made to translate and examine these works.

Many students do not understand the basic concepts and terms present in Hindu mathematics. They believe that all advances in mathematics come from Western and Arabic traditions but do not realize that important concepts such as the decimal number system and the number zero originate from Hindu mathematics. Many important discoveries in the history of mathematics are not recognized because of historical narratives dominated by Western

perspectives (Seidenberg, 1967). Due to this ignorance, people do not appreciate the rich mathematical heritage of various cultures.

Many works on the history of mathematics privilege Western and Arab figures such as Euclid and Al-Khwarizmi, while important Indian figures such as Brahmagupta are rarely recognized. The lack of in-depth resources on Hindu mathematics contributes to students' difficulty in recognizing and understanding the important contributions of this tradition (Singh, 2011).

In addition to the lack of resources on Hindu mathematics, education systems around the world fail to thoroughly incorporate their contributions into the curriculum. Many textbooks only mention the number zero or the decimal number system without explaining how Hindu mathematicians helped develop them. As a result, students do not have a deep understanding of how these ideas developed and how they impact contemporary mathematics (Plofker, 2009). Students would benefit from a broader historical perspective of mathematics through better integration of these contributions into the curriculum.

Finally, the situation is worsened by the fact that important figures in Hindu mathematics are not promoted or recognized in the media and academic publications. Understanding the history of mathematics as a whole is easier for students because they are usually more familiar with the research findings of Western mathematicians. Therefore, in order to make society appreciate the diverse and rich heritage of mathematics, it is imperative to diversify the narrative of the history of mathematics and increase the visibility of contributions from traditions that are often overlooked. In addition to increasing knowledge about the history of mathematics, these efforts will inspire future generations to study and appreciate contributions from different cultures.

How we understand mathematics is influenced by our culture, and the contributions of different cultures often go unnoticed in the dominant history of mathematics. For example, formal education often ignores Hindu mathematics, which significantly contributed to the development of the decimal number system and the concept of zero. Students can have a limited understanding of intellectual diversity in the world if the history of mathematics does not sufficiently diversify this story. Mathematics is a product of human culture that developed through interactions between different societies around the world (Joseph, 2011), suggesting

that every culture, including Hindu culture, made significant contributions to the advancement of modern mathematics.

Efforts to diversify the historical narratives of mathematics are also very important to enrich students' learning experiences and encourage them to better appreciate the contributions of different cultures to the development of science. Recognizing the contributions of different mathematical traditions not only enriches our knowledge but also builds a broader understanding of global history (Katz, 1993).

CONCLUSION

Hindu mathematics played a pivotal role in the development of modern arithmetic, particularly through the introduction of zero by Brahmagupta and the decimal number system. These innovations enabled efficient calculation methods and laid the groundwork for modern mathematical systems. However, this study found that students possess limited knowledge of Hindu mathematics and its historical significance. This gap stems from the dominance of Western and Arabic narratives in curricula and the scarcity of accessible teaching resources on Indian mathematical heritage.

A further challenge lies in the limited availability of systematic documentation and the complexity of original Sanskrit texts, which can hinder integration into modern education. Moreover, the practical nature of many Hindu mathematical contributions, in contrast to the abstract formalism emphasized in Western traditions, has led to their historical under recognition. To address this, educational institutions should integrate the history and contributions of Hindu mathematics into curricula and develop accessible, student-friendly resources. Doing so will promote a more inclusive understanding of mathematical history and enrich students’ appreciation of diverse intellectual traditions.

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