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AL-KHAWARIZMI: A MUSLIM SCIENTIST WHO DISCOVERED ALGORITHMS AND THEIR INFLUENCE IN THE DEVELOPMENT OF MODERN COMPUTATION

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ABSTRACT

The development of computer technology to its current level of sophistication is not separate from the contribution of a Muslim scholar who was focused on the field of mathematics. The scholar was named Abu Ja'far Muhammad bin Musa al-Khawarizmi or better known as Al Khawarizmi. This research used a qualitative research method with a literature review design. In using the literature review research method, the researcher will go through stages consisting of identifying the topic and problem to be studied, searching for sources related to the discussed and determined problem, selecting sources relevant to the topic and problem being studied, collecting data from the selected sources, analyzing the collected data, and writing a report on the results of the literature review. The conclusion of this research is that Al Khawarizmi did play a role in the development of current computer technology. This is evidenced by several discoveries made by Al Khawarizmi which are actually used in the field of computer science, including algorithms and the number zero. The algorithm has a very important role in computer programs.

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Keywords: Al Khawarizmi, Algorithm, Computation, Modern.

INTRODUCTION

The sophistication of technology that we experience and use today truly helps to simplify daily tasks and activities. Some of the advancements in technology are computer technology which continuously develops according to the times. However, do we know that the development of computer technology to its current state is actually due to the contribution of a Muslim scholar who was focused on the field of mathematics? This Muslim scholar is known as Abu Ja'far Muhammad bin Musa al-Khawarizmi, or more commonly referred to as Al-Khawarizmi (Mulyadi, 2018).

Al-Khawarizmi was a Persian mathematician, astronomer, and geographer who lived during the 9th century under the rule of the Abbasid dynasty in Baghdad. He is considered a pioneering Muslim scholar in the development of mathematics and astronomy. (Putri, 2019; Striphas, 2015). Al-Khawarizmi is regarded as one of the most important figures in the history of mathematics and computation because of his numerous contributions that have influenced the development of modern science and technology.

As we all know, Al-Khawarizmi made numerous contributions to the development of mathematics. In addition to mathematics,

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modern technology is another field that greatly benefited from Al-Khawarizmi's contributions.

Abdelwahab et al., (2014) The algorithms and algebra formulated by Al-Khawarizmi have become the foundation for the development of the sophistication of computer technology, digital technology, and encryption. The rapid development of modern industry today can undoubtedly be attributed to the contribution of the world's Muslim mathematicians, including Al-Khawarizmi. Algorithms and algebra have had a significant impact on modern technology industries. Without algorithms and algebra, it can be said that technology industries would not have been able to develop as they have today.

Around the 11th century, Arab mathematics was one of the strongest foundations of knowledge in the world. Many Muslim scholars at that time were focused on developing various fields of knowledge, including mathematics. Al Khawarizmi was one of the Muslim scholars who contributed greatly to the Renaissance and the revolution of scientific development in Europe.

Al Khawarizmi and other Muslim mathematicians of his time successfully discovered algebra and geometry, and then brought them into a complex and advanced mathematical realm. This was demonstrated by Al Khawarizmi and Muslim mathematicians of that era who were able to solve complex and difficult mathematical problems, including solving third and fourth-degree equations. These works were translated into European and Latin languages, leading the world into a new phase of scientific development known as the Renaissance.

Al Khawarizmi's works, which were widely translated into European and Latin languages, had a significant impact on the development of mathematics. This is evidenced by the widespread recognition of Al Khawarizmi's works on the European continent, as well as their use as standard mathematics texts in European universities until the 16th century. In the English translation, Al Khawarizmi's works introduced new terms such as "algjebar", "almachabel", and other naming versions. Until now, these terms are known as "algebra" and are still used today. This proves that mathematics in the Western world was truly influenced by Al Khawarizmi's works in the 16th century.

MATERIALS AND METHODS

This research employs qualitative research method with a literature review design. Literature review is a research method used by researchers to gather, analyze, and evaluate previous sources related to the topic being studied. In this method, researchers conduct a study of previously published literature, which can include scientific journals, books, reports, and other online sources. This method is used to collect information from documents, books, and literature that have been previously published and critically evaluate them in order to draw useful conclusions for the research being conducted.

The literature review method can be used in the study of "algorithms and their impact on modern computing" because this study requires an analysis of previous literature on algorithms and their impact on modern computing. With this method, researchers can gather relevant information and critically evaluate it in order to draw useful conclusions for the research being conducted.

In using the literature review research method, researchers will go through the following stages: identifying the topic and problem to be studied, searching for sources related to the chosen problem, selecting sources that are relevant to the topic and problem being studied, gathering data from the selected sources, analyzing the collected data, and preparing a report of the literature review results. In general, the research process can be depicted in the following flowchart.

RESULTS AND DISCUSSION

Biografi Al Khawarizmi

Mohammad ibn Musa Al Khawarizmi (780–850), or better known as Al Khwarizmi was a mathematician, astronomer, and geographer during the Abbasid Caliphate. He is a scholar at the House of Wisdom in Baghdad (Buranovich, 2021). In the 12th century, a Latin translation of his work on Indian numerals introduced the decimal number system to the

Western world. The Compendious Book on Calculation by Completion and Balancing by Al Khawarizmi resents the first systematic solution of linear and quadratic equations in Arabic. He is often considered one of the fathers of algebra (Mehri, 2017).

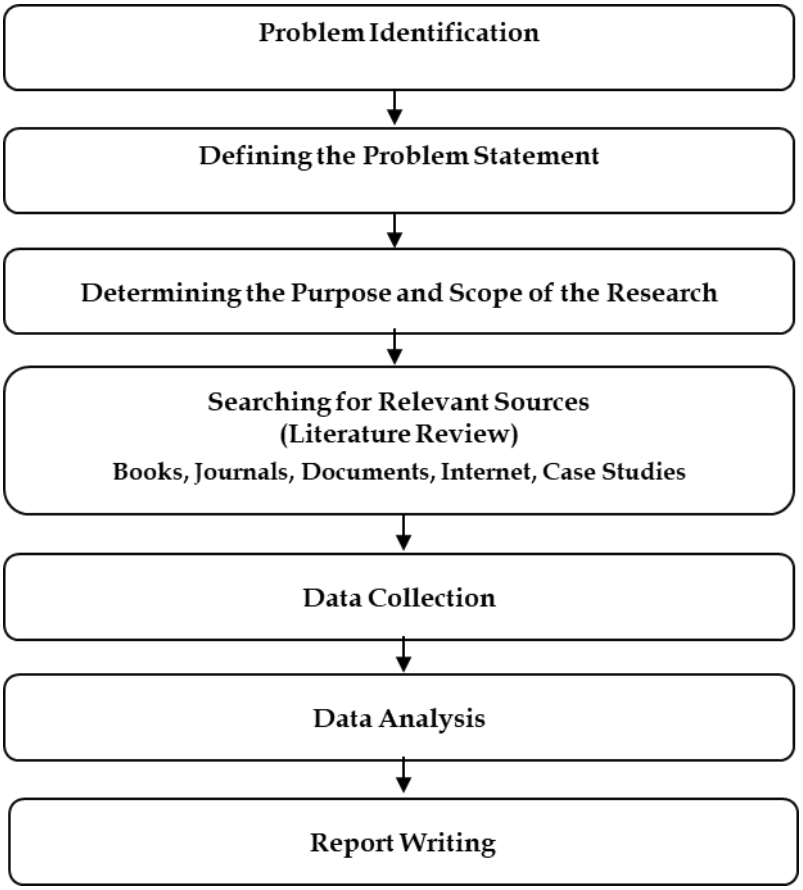

Figure 1 Research Chart

Al Khawarizmi alias Algorithm was an intellectual from the 8th to 9th centuries who made significant contributions to the development of algebra. Al-Khawarizmi was born in 783 AD in Khwarizm in Persian Southwest Asia, which is today the city of Khiva in Uzbekistan. Al Khawarizmi was very influential in the development of algebra throughout Southwest and Central Asia, North Africa, and Europe, which in turn influenced the development of medieval and modern algebra and mathematics throughout the world. It would be of great benefit to any high school or college algebra instructor to be able to impart some of this historical knowledge to the students in the class.

Nabirahni et al., (2019) The author is interested in sharing Al-Khawarizmi background with other mathematics teachers as he believes this will make mathematics more interesting and engaging for students, which can lead to higher levels of achievement for students along with an increased appreciation of the contributions of Persian mathematics.

As already explained that Al Khawarizmi lived in an era called the Islamic Golden Age, namely between the 8th and 13th centuries. Contributing to the Persian Golden Age, Al Khawarizmi lived a very pious and intellectual religious life (Faruqi, 2015). In 830 AD, he began studying under the Caliph Al Ma'mun, who reigned from 813 to 833 AD. Al Khawarizmi's studies took place at the Bayt al-Hikma, or House of Wisdom, in Baghdad. The Bayt al-Hikma founded by Al Ma'mun contained a research library and an observatory where many scholars studied (Nabirahni et al., 2019). At that time Caliph Al Ma'mun had the goal that Bayt al-Hikma be used as a place where all Greek texts could be translated into Arabic and/or Persian.

Baghdad became a central location for science and commerce, attracting scholars mostly from Persia and as far away as China and India.

Around 830 CE, Al Khawarizmi wrote a remarkable mathematical work in an attempt to provide Persian and Muslim halves of mathematics with assistance in solving problems of inheritance, partition, lawsuits, inheritance, and commerce. His extraordinary work, namely al-Kitab al-mukhtasar fi hasab al-jabr wal-muqabala, translated as The Compendious Book on Calculation by Completion and Balancing, is considered the first algebraic book (Murmamatovna, 2020; Oaks, 2012).

The word "al-muqabala" in the title of the book refers to the balancing operation. The word algebra comes from the "al-Jabr" (literally, to impose) in the title of his book, which al Khwarizmi uses to describe the solving operation (Heeffer, 2008). In the second part of the book, al Khwarizmi writes about measurement. It gives the steps for solving the areas of plane shapes such as circles and solving the volumes of solids such as truncated pyramids. The third part of the book is the longest and consists of solved problems regarding inheritance. Solutions involve arithmetic and simple linear equations. However, knowledge of Islamic jurisprudence regarding inheritance law is necessary to understand the problem (Oaks, 2012).

Al Khawarizmi is not only recognized for his contributions in mathematics, but also in other fields such as astronomy. Al Khawarizmi was one of the first scholars to draw a map of the world and create astronomical tables. Schematic tabulation is used to find the positions of stars and planets using calculations (Meraj, 2018). Al Khawarizmi's most famous astronomical work is Zij al-Sindhind, translated as Sindhind Astronomical Tables The table was written around 820 AD and is partly based on Indian astronomical study methods (Sparavigna, 2013). The text includes astronomical tables for determining the magnitude of a solar eclipse and finding the speeds of the sun and moon and their apparent diameter.

Since Al Khawarizmi was interested in astronomy, he wrote a treatise on the Jewish calendar entitled Risala fi istikhraj ta'rikh al-yahud, translated as Extraction of the Jewish Era (Duran & Samanci, 2018). In this text, Al Khawarizmi explains the features of the Jewish calendar such as the 19-year Metonic cycle, the process of determining which Tishri day should fall, and the steps of using the calendar to determine the mean longitude of the sun (Hazmy et al., 2016).

The text also includes calculations of the time period between the Jewish era and the Seleucid era. It took another three centuries when another Persian mathematician-philosopher-poet Omar Khayyam corrected the solar calendar called Jalali to 365 days and six hours. Al Khawarizmi also wrote two texts on the astrolabe, the Kitab 'amal al-asturlab, translated as the Book of Construction of the Astrolabe, and the Kitab 'amal bi'lasturlab, translated as the Book of Astrolabe Operations (Nabirahni et al., 2019).

Al Khawarizmi's geographical text, Kitab surat al-ardz, translated as The Speed of the Earth, was written in 833 AD. In this text, Al Khawarizmi gives latitudes and longitudes for 2402 places and divides these places into six parts namely seas, mountains, islands, rivers, cities and regions. In each section, all places are set in a certain. The climata are the seven parts of the world divided by longitude as seen in ancient Greek. Al Khawarizmi understood information from Ptolemy's geographical works, but Al Khawarizmi's geography of Southwest Asia was more detailed and more accurate than Ptolemy's (Mehri, 2017).

Ptolemy's length of the Mediterranean Sea was too long, and Al Khawarizmi corrected it. Ptolemy circumnavigated the Atlantic and Indian oceans by land, describing them as seas. Al Khawarizmi, on the other hand, does not limit the sea to land. Al Khawarizmi wrote another summary which has not survived called Kitab al-ta'rikh, translated as Chronicle; it is a record of events that took place in Southwest Asia according to astrology (Hazmy et al., 2016). It has been noted that Al Khawarizmi used the astrological methods of this text to find out the hour at which the Prophet Muhammad was

born according to the astrological events of his life. Another text that has not survived is the Kitab al-rukhnama, translated as On the Sundia. Only the title of this text is known, but the subject of the title seems to suit Al Khawarizmi's interests.

Algorithms and Computer Technology

Mark Zuckerberg, the founder and CEO of Facebook, once made a statement "I'm amazed that there are people who idolize me too much, while I greatly admire Muslim scientist Al-Khawarizmi. Because without algorithms and algebra, don't even dream of having Facebook, Whatsapp or even computers. You should be proud to be a Muslim." (Yusuf, 2022). From Mark Zuckerberg's words, one Muslim scientist named Al-Khawarizmi emerged, and directly in his statement, Mark Zuckerberg acknowledged that Al-Khawarizmi was an extraordinary scientist, the progenitor of all computer technology discoveries today. Where all human beings truly feel the ease with the existence of current technologies. This certainly cannot be separated from the research and discoveries made by Al-Khawarizmi.

There are many connections between the history of algorithms and the history of mathematics. In modern times we know it in English as "algorithm" derived from the name Al-Khwārizmī which was later Latinized to "algorithm". (Bleakley, 2020; Kadam & Kadam, 2014). People familiar with the history of mathematics may know "Al-Khwārizmī'" because he is known as the author of book-Kitāb al-Mukhtaṣar fī Ḥisāb al-Jabr wal-uqābalah (Book of Summary of Calculations by Solutions and Balancing), one of the most ancient ancient mathematical texts. Famous written in Arabic from which the term "algebra" comes (Makhmudov, 2018).

One of the greatest contributions of Al-Khawarizmi is the discovery of the algorithm. The concept of algorithm was first introduced by Al-Khawarizmi in his book titled "Al-Kitab al-Mukhtasar fi Hisab al-Jabr wal-Muqabala" or also known as "The Compendious Book on Calculation by Completion and Balancing" (Perkasa et.al., 2021). In his book, Al-Khawarizmi introduced a mathematical method based on the decimal number system and provided practical examples of how to use algorithms to solve mathematical problems such as calculating the area of geometric shapes or finding square roots.

Figure 2 A page from Al Khawarizmi "Algebra"

The concept of algorithms introduced by Al-Khawarizmi is very important in the development of modern computer technology. Algorithms are used in software, search engines, artificial intelligence, and many other applications. The use of algorithms helps to improve efficiency and accuracy in data processing and enables the development of more complex applications (Harianja, 2019). The use of algorithms also allows for the development of more complex applications. In application development, algorithms are used to implement various features and functions. By using algorithms, developers can design more complex applications with advanced and sophisticated features.

Algorithms can also be adapted for use in various types of applications, such as applications in artificial intelligence, image processing, and natural language processing (Nurnaningsih & Permana, 2018). The use of good and efficient algorithms is crucial in data processing and the development of modern applications (Amalia & Rosyani, 2018). A well-designed algorithm can help improve efficiency and accuracy in data processing and enable the development of more complex applications with advanced features.

Al-Khawarizmi was first known to the European world around the year 1140 AD. He began to be recognized when Robert Chester translated Al-Khawarizmi's works into Latin under the title "Liber Algebras et Almucabola" (Mulyadi, 2018). Until now, the concept of Al Khawarizmi is still widely used in the fields of mathematics and computer science, known as algorithms. An algorithm is defined as a logical sequence of decision-making for problem-solving (Nurnaningsih & Permana, 2018). In the current development of advanced computer technology, algorithms play an essential role. Even Artificial Intelligence (AI), which is considered to be a technology that can match human intelligence, cannot be created without the concept of programming algorithms (Magdy, 2021).

The algorithm discovered by Al-Khawarizmi is a result of his thought that made something impossible in modern science become possible today. An algorithm is a systematic and logical set of steps designed to solve a problem. It is structured and designed logically and systematically. In algorithms, logic is the key factor that must be present (Nurnaningsih & Permana, 2018; Brower, 2020; Makhsud, 2021). This is because algorithms must be logical and their truth value (true or false) can be determined. Algorithms can also be defined as sequential steps in carrying out certain tasks.

The advancement of modern computer technology today cannot be denied due to the contribution of algorithms. A computer programmer will always use algorithms in creating and developing programs. Algorithms play a significant role in the development of computer technology, especially computer programs.

The development of computer programs today also cannot be separated from the contribution of the algorithm concept discovered by Al Khawarizmi. Algorithms play a significant role in computer program development. A program is a set of computer statements, and the systematic stages in a computer program are algorithms. Thus, it can be said that computer programs are composed of algorithms and language (data structures). (Mauliani, 2020; Cardon, 2018). Algorithm and data structure are two interconnected things in program development. A good algorithm without the proper selection of data structure will make the program less efficient, and vice versa. Algorithm is an organized process created to produce solutions or answers to a problem. The process generates solutions in defined steps. Algorithm is a procedure where each step aims to solve a problem (Amalia & Rosyani, 2018; Cardon, 2018). Algorithm is defined as a systematic procedure composed of logical and systematic steps to solve a problem through decision-making to provide a solution.

In a set of questions/problems, algorithms are always present to solve them with certain limitations created by the algorithm itself. An algorithm is a planned procedure that is systematically arranged with the aim of solving a problem with an instruction. The word algorithm basically comes from "Algoritmi", which in Latin is taken from the name of Al Khawarizmi himself. In the development of computer science, an algorithm is a process created to solve computational problems with the best possible designed criteria (Perdana, 2018; Murmamatovna, 2020). The development of algorithms plays a crucial role in all branches of computer science, such as database, artificial intelligence (AI), networks, security, operating systems, and other computer science fields.

Algorithms enable programmers to provide instructions to computer logic in the form of specific steps or instructions to carry out a task and solve a problem. Algorithms are not limited to programming and can be applied in various fields (Amalia & Rosyani, 2018; Li et al., 2018). This requires alternative understandings to solve computational problems, including networks, hardware, programming languages, and performance constraints in solving specific solutions. It is important to note that computers cannot do anything without us telling them what to do, and algorithms help with that. Algorithms assist programmers in providing steps and commands to complete tasks and find solutions to solve a problem.

From the explanations above, it can be concluded that algorithms have a significant

impact on the development of computer technology up to the present time. Algorithms help computer programmers enter commands into the computer to solve problems. Algorithms help programmers create applications that help and facilitate humans in their daily lives.

The Number "0" and Computer Technology

In addition to his discovery of algorithms, Al-Khawarizmi also made significant contributions to the development of algebra and trigonometry (Mulyadi, 2018). He introduced the concept of algebra and provided mathematical proofs of trigonometric formulas still in use today. Another contribution is the development of the Hindu-Arabic numeral system, which is used in the modern decimal number system used worldwide. Al-Khawarizmi is also known as a pioneer in the study of probability and statistics. He discussed theories of probability and statistics in his book titled "Kitab al-Jam'a wal-Tafriq bi Hisab al-Hisab", which provided the basis for the development of modern statistics (Islam, 2011; Boucard & Morel, 2022).

Overall, Al-Khawarizmi is an important figure in the history of mathematics and computation. His contributions to the development of algorithms, algebra, trigonometry, the Hindu-Arabic numeral system, and probability and statistics theory have had a significant impact on the advancement of modern science and technology (Mollah, 2017; Mutijah, 2018; Sari & Araiku, 2020). Therefore, understanding the works of Al-Khawarizmi is crucial for the development of science and technology today. Another equally great contribution from Al-Khawarizmi in the field of computer is the invention of the idea of the number 0 in the Arab numbering system. Al-Khawarizmi introduced and popularized the number "0" (zero). He was the first person to explain the usefulness of numbers, including the number "0" (zero) (Mehri, 2017; Nurjanah dkk., 2021).

Al-Khawarizmi's work on arithmetic is documented in a book entitled "Al Jam' wat-Tafriq bi Hisab Al Hind". In this book, Al-Khawarizmi also explains the concept of calculation, addition, and subtraction according to the Hindu calculation. The use of the Hindu calculation, which starts from 1-9 and is also added with the concept of the number "0" (zero), is also discussed in the book (Dutta, 2015; Mulyadi, 2018). In his book, Al-Khawarizmi discussed the history of numbers. Through his phenomenal work, Al-Khawarizmi's ideas were used by Europeans, especially the use of the number "0" (zero) to facilitate calculations, especially for tens, hundreds, thousands, and so on (Aksoy, 2016).

The development of the number 0 has increased its function in various fields of life, starting from the notation of tens, hundreds, and so on. This determines that the number 0 enlarges the value of existing numbers. Although the number 0 itself has the meaning of "zero" (Aksoy, 2016). Before the existence of the number 0, the notation for tens used symbols as markers only. In the history of the discovery and development of the number 0, one of them is the discovery of Calculus theory. This theory allows for the calculation of probabilities in the future, for example predicting the spread of the Ebola virus and calculating economic profits. In the field of technology, the number 0 is a very important number. The history of programming languages proves that at the beginning of computer development, everything was in machine language. Binary code is the content of machine language consisting of the numbers 0 and 1.

As time goes by, it turns out that the number 0 has become a number that is widely used and adapted in computer technology. The number zero is used in computer programming, namely binary coding. Binary coding, or more commonly known as the binary operating system, makes "0" (zero) as its basis. The binary operating system is a set theory used in the computer field that allows the creation of combinations of the numbers 0 and 1, so that logical functions of the computer can be created that can solve calculations automatically (Herwanto, 2019). Binary is a number system with base two, which is a system of writing numbers using only two symbols, namely "0" and "1". The binary system is used in computers as a sign of true or false, an indicator between one or two places, or positive and negative.

The number 0 plays a significant role in modern computer technology because it is part of the binary number system used by computers for calculations and data storage. The binary number system only consists of two digits, 0 and 1, and is used by computers because it is easier and more efficient for electronic data processing. In the binary number system, each digit represents a different value based on its position. The rightmost digit represents a value of 1, while each digit to the left represents a value that is twice the value of the previous digit. For example, the binary number 1 0 1 0 represents the value 10 in the decimal system because it consists of the digits 0, 1, 0, and 1 that represent the values 0, 2, 0, and 8, respectively.

In modern computing, the use of the binary number system consisting of 0 and 1 is the foundation of electronic data processing. This system allows computers to perform mathematical operations, store and retrieve data, and process graphics more efficiently and accurately. Additionally, the number 0 is also used in algorithm development and artificial intelligence. An algorithm is a set of instructions used by a computer to perform a task, and often uses binary numbers and the number 0 as a basis for processing data correctly. Artificial intelligence also uses the number 0 as a basis for developing machine learning systems and neural networks to process data automatically.

Thus, it can be concluded that the number 0 plays a crucial role in modern computer technology as it is a part of the binary number system used by computers to perform mathematical operations, store data, and process graphics more efficiently and accurately. Additionally, the number 0 is also utilized in the development of algorithms and artificial intelligence to process data automatically.

CONCLUSION

Based on the findings and discussions that have been clearly outlined above, it can be concluded that Al Khawarizmi did play a role in the development of current computer technology. This is evidenced by several of Al Khawarizmi's discoveries that are actually used in the field of computer science, including Algorithms and the number zero.

Algorithms have a significant role in computer programs. Programs are a collection of instructions or code written in a specific programming language and used to control and manipulate hardware and software on a computer, while the systematic steps in computer programs are algorithms. Meanwhile, the number zero is a number that is truly used and adapted in computer technology. The number zero is used in computer programming, namely binary coding. Binary coding, or better known as the binary operating system, makes "0" (zero) as its basis. The binary operating system is a set theory used in the field of computers that enables the creation of combinations of numbers 0 and 1, so that logical computer functions can automatically solve their calculations.

Author's declaration

Authors' contributions and responsibilities

The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation and discussion of results. The authors read and approved the final manuscript.

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Competing interests

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