

Mathematics Pre-Service Teachers' Understanding on Oughtred and His Inventions

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Abstrak

Penemuan William Oughtred berupa alat peraga yang disebut slide rule membuat matematika terus berkembang. Slide rule membantu para ilmuwan dan teknisi dalam melakukan perhitungan matematika kompleks, serta membuka jalan perkembangan teknologi baru. Tujuan penelitian untuk memotivasi, memberikan informasi, dan mengetahui pengetahuan mahasiswa calon guru mengenai matematikawan Oughtred dan penemuannya. Penelitian berjenis kualitatif dengan metode literature review dan studi kasus. Literatur review didapatkan dari beberapa jurnal yang berhubungan. Teknik pengumpulan data dilakukan dengan menelaah, menganalisis, dan mengelompokkan sehingga diperoleh kesimpulan. Studi kasus didapat dari wawancara terhadap subjek penelitian, yaitu 10 mahasiswa prodi pendidikan matematika. Instrumen berbentuk wawancara terbuka. Setiap mahasiswa diberikan pertanyaan mengenai pengetahuan tentang William Oughtred dan penemuannya. Analisis data dilakukan dengan meta analisis dan analisis tematik. Hasil penelitian menunjukkan terdapat tiga kategori respon mahasiswa pendidikan matematika terhadap topik wawancara. Kategori tersebut yaitu Know History Oughtred, Forget History Oughtred, dan Indifferent to History Oughtred.

Kata Kunci: Matematika; Oughtred; Penemuan; Sejarah; Slide Rule.

Abstract

William Oughtred's invention in the form of a teaching aid called the slide rule made mathematics continue to develop. Slide rules help scientists and technicians perform complex mathematical calculations, and pave the way for new technological developments. The research aims to motivate, provide information, and find out the knowledge of prospective teacher students about the mathematician Oughtred and his findings. Qualitative research used literature review and case study methods. Literature reviews were obtained from several related journals. Data collection techniques are carried out by examining, analyzing, and grouping conclusions obtained. Case studies were obtained from interviews with research subjects, namely 10 students in a mathematics education study program. The instrument is in the form of an open interview. Each student is given questions regarding knowledge about William Oughtred and his discoveries. Data analysis was performed by meta-analysis and thematic analysis. The results showed that there were three categories of mathematics education students' responses to the interview topic. These categories are Know History Oughtred, Forget History Oughtred, and Indifferent to History Oughtred.

Keywords: History; Invention; Mathematics; Oughtred; Slides Rules.

I. INTRODUCTION

William Oughtred was an English mathematician, born in Eton, Buckinghamshire (now part of Berkshire), on March 5, 1574. William Oughtred was famous for his contribution to the historical development of mathematics. Despite an Episcopal minister, he taught mathematics to highly motivated students for free. His students were John Wallis, Christopher Wren and Seth Ward who later became famous and experts in the fields of mathematics, architecture and astronomy (Keguruan et al., 2018). In the 17th century, Oughtred, who was also interested in alchemy and astrology, published a renowned work, namely *Clavis Mathematicae* which was used by Wallis and Isaac Newton. In this book, Oughtred introduced the symbol (\times) for multiplication (Fuentes, 2017; Padmanabhan et al., 2019).

Other works were *Equinoctial Universal* about two rings, and *Opuscula Mathematica* related to trigonometry which was noteworthy to introduce trigonometric functions. In this century, Oughtred also established algebraic notations *Karya lainnya yaitu Equinoctial Universal* (Susilawati, 2017). In his life, more than 150 symbols were published. Before the time of the calculator, William Oughtred invented the slide rule (Ben, 2014).

William Oughtred's invention of the slide rule was the basis of the development of a calculating tool to perform more complex mathematical calculation. The earliest slide rule was a simple mechanical device that used the principle of logarithms and was able to perform various kinds of mathematical calculations with a high level of accuracy (Liddicoat, 1943).

Prior to the slide rule, complex mathematical calculations had to be done manually using tables of logarithms and simpler mechanical calculators, such as abacuses and other calculating tools (Boyer & Merzbach, 2011). This process was time-consuming and required excellent mathematical skills. With the slide rule, complex math calculations could be done easily and quickly even for those who were beginners at math.

The use of the slide rule has helped scientists, engineers, and technicians perform complex mathematical calculations in various fields such as navigation, civil engineering, and other technologies. In addition, the invention of the slide rule also opened up new path ways for other calculating tools, such as computers and calculators that we use today (Furr, 2000).

Regarding the contributions of William Oughtred's inventions in mathematics, students are encouraged to learn and look for various sources about William Oughtred and his inventions. However, there are many students who do not recognize the infamous mathematician, namely William Oughtred and his contributions to mathematics until the present days.

There are few sources of information or studies discussing William Oughtred and his inventions. The general knowledge of William Oughtred is that he was a British mathematician who invented the slide rule. Therefore, the author presented a glimpse of mathematician William Oughtred and his inventions and explore the extent of knowledge of today's millennial students regarding the infamous mathematician and his inventions.

Students' categories regarding William Oughtred and his discoveries are in accordance with today's life where many millennials have no interest in the history of mathematicians, but there are also few students who possess curiosity to explore the originality of meaningful inventions and there are also some students who have no any interest to understand the history behind the inventions.

Millennial students are experiencing "historical amnesia" or the state in which someone is forgetting the history (Lacey, 2019). Some factors, such as a lack of emphasis on history in the school curriculum, the proliferation of digital technologies, and a lack of access to reliable historical resources, contribute to this phenomenon (Frantz, 2018).

It should be motivated and encouraged to study the history of mathematicians, especially Oughtred, and be exposed to such issues, inspired by the perseverance and tenacity of mathematicians that may have an impact on the progress of the nation.

II. METHODS

The study employed a qualitative research design with literature review and case study methods. 1) Literature review is a method used to combine the findings of two or more studies which aims to review and summarize previous studies. The data obtained in this study were secondary data, namely data obtained indirectly. 2) Case study is research in which the data is entrusted to collect non-numerical data. The data collection process was carried out through meta-analysis obtained from

various journals, and internet sites that were in accordance with the topic of mathematician William Oughtred and his inventions. In addition, the study was conducted by interviewing five classes from the mathematics education study program, each class selected 2 students regarding the extent of their knowledge of mathematician William Oughtred and his inventions in mathematics.

This study aimed to determine students' knowledge about the contribution of the infamous mathematician, William Oughtred, and his inventions. The instrument used was an open-ended interview. Interviews were conducted to obtain accurate and effective data sources. The analysis of the data was conducted by exploring deeper information regarding William Oughtred and his inventions, parsing data into units, categorizing the data to draw conclusions to be presented. The data analysis process began with the author asking questions regarding the main topic to the participants.

III. RESULTS AND DISCUSSION

A. Who was William Oughtred and what were his inventions?

William Oughtred (1574-1660) was the most famous scientist in the historical development of mathematics in the 17th century. He studied at Eton College and King's College, Cambridge. His first career was as a teacher of mathematics. Oughtred's contributions to mathematics have flourished mathematics to the present days. Among them are the following:

1. Mathematic symbols

In the 17th century (1574-1660), in Clavis Mathematic, William Oughtred introduced the symbol (\times) as the term for multiplication (Fuentes, 2017). The sign (\times) as a multiplication symbol seemed very difficult to approve due to its similarity to the alphabet x. At that time, the symbol for multiplication was the dot (\cdot), a notation used by Harriot. However, the symbol was not widely applied. This symbol was only widely used after Leibniz's approval. The sign in geometry, the symbol ($-$) used to express "approximating", was originally used by Oughtred to express "difference". The symbol ($-$) to express "approximating" and the symbol (\approx) to express "congruent" were determined by Leibniz (Wijayanti, n.d.)

The Oughtred's contributions in the development of mathematical notation are presented in Table 1.

Table 1.
Symbols developed by Oughtred

No	Symbol	Meaning
1.	(\times)	Multiplication
2.	($::$)	Comparison
3.	($-$)	Difference
4.	(\approx)	Congruent
5.	(π)	Perimeter comparison
6.	($:$)	Division

These symbols are still used. They introduce other functions of symbols in mathematics including some advantages by understanding the structures more broadly and diversely, helping us solve problems appropriately, and making communication more efficient and effective.

2. Sine Rule and Tangent Rule

Oughtred also discovered the sine rule and tangent rule, which are mathematical formulas used to calculate the length of the

sides of a triangle using known angles. (O'Connor & Robertson, 2017) These discoveries are very important in mathematics and have been used in various fields such as astronomy, navigation, and engineering until today.

The tangent rule is used to calculate the distance and direction between two objects in space and applied in modern navigation tools like GPS to calculate position. The tangent rule also allows astronomers to ensure the accuracy of their measurements and navigation (Starchan & Sluzek, 2014).

3. Slide rule

In 1622, Oughtred published the logarithm slide rule. Because calculators did not exist at that time, Oughtred created the slide rule. The purpose of creating the slide rule is to do logarithm problems of multiplication and division with addition and subtraction. Mathematicians had to find two logs, add them together and then find the number which log was the sum. Edmund Gunter reduced the process by drawing a number line where the places of numbers were proportional to their logs.

Then William Oughtred simplified the rule with the slide rule, in which the user took two Gunter lines and slid them relatively to each other to eliminate the divider. The Slide Rule was created by William Oughtred based on Napier's Bones. He made the first slide rule using inscribing logarithms on wood or tusks (Bellis, 2014). Slide Rule had been used for centuries until mechanical and electronic calculators were invented (Dirgantoro, 2017). The slide rule consists of circular (1632) and rectangular (1620) slide rules (Oughtred et al., 1859).

Major improvements to the slide occurred in 1815 and 1859. The demand for

the calculating tool was the highest during 1884 and 1945, after which computers and electronic calculators replaced the slide as the primary mathematical tool for engineers (Scuria & Fontana, 1993).

Oughtred's Slide Rule rolled out in various forms in Europe during the 17th century, its invention coinciding with the invention of the \times sign as a multiplication symbol. Before the invention of the calculator, the slide rule was a popular tool for calculations. The use of the slide rule continued until around 1974, after which electronic calculators became more popular until now (Oughtred et al., 1859).

The use of slide rules helped students understand math concepts comprehensively. The introduction of the slide rules to the students might improve math problem-solving skills, as well as provide a better understanding of the history of technological and mathematical development (Lai & Wiesenfeld, 2011).

Oughtred's other contribution was the logarithms developed in the 17th century. Oughtred's method of calculating logarithms differed from Briggs in several ways. He used a different method of interpolation, which involved adding differences to obtain logarithms, whereas Briggs subtracted them. Oughtred also used "hyperbolic logarithms" which were logarithms with base e (natural logarithm) rather than base 10. However, he recognized the equivalence of the two systems and showed how to switch between them (Berggren, 1981).

B. Categories of Students Based on Case Studies

Based on the interviews and observations, the author described the answers of each participant to the questions given. In this study, results regarding the extent of students' knowledge of mathematician William Oughtred and his discoveries were presented.

DA was part of class A delivered of his knowledge regarding William Oughtred and his inventions as following.

"From what I've read, Oughtred was a mathematician whose discoveries are very important in mathematics, one of his inventions is the slide rule in mathematics, which is a calculating tool that used to be very useful for difficult calculations"

MDP, from class A, shared her opinion regarding William Oughtred and his invention.

"I know a little about Oughtred, he was a mathematician and a priest from England. Oughtred's invention was the sliding logarithm rule. His other work is *Clavis mathematicae*, in this book he explained the Hindu-Arabic mathematical notation system, the theory of decimal fractions, and algebra."

Following extract was from class B, TA, sharing an opinion about William Oughtred and his inventio.

"I don't know about the mathematician, Oughtred, because I really don't like history, let alone finding out about these experts, I just use existing formulas without finding out the person who discovered the formula"

HFR, from class B, expressed that he only knew that Oughtred was a mathematician

from England, but did not know what the mathematician's discoveries were.

"As far as I know, Oughtred is a mathematician from Europe, if I'm not mistaken, England. I don't know much about his discovery, but I have heard or read his name before."

Furthermore, a student from class C, APP, expressed her opinion about mathematician William Oughtred and his discovery.

"I once read a book about some experts (in mathematics), if I'm not mistaken Oughtred was a British mathematician who played an important role in the early days of mathematics, but I forgot what his discoveries were."

MH, from class C, shared his knowledge of William Oughtred and his inventions as following.

"I don't know William Oughtred including what his inventions are, and I just heard for the first time because of this interview question"

NNA, who came from class D, expressed her opinion about mathematician William Oughtred and his invention as following.

"I don't know the mathematician William Oughtred and have never heard of his name and discoveries, but I know mathematicians like Phytagoras, Aristotle, Archimedes.."

The opinion of PY from class D, is also the same as NNA's opinion where PY also did not recognize the mathematician William Oughtred and his discovery.

"I didn't recognize this mathematician, nor his invention."

HB from the international class expressed his opinion on the extent of his knowledge of mathematician William Oughtred and his inventions.

"From various sources of books that I read about mathematicians, what I know is that Oughtred is an English mathematician born in Eton who participated and contributed to the development of mathematics in the 17th century, he developed many symbols, slide rules and many more."

AJ, from the international class, had the same opinion as HB.

"I also agree with HB, I have also read that Oughtred has brought mathematics and taught it willingly to anyone who is interested in learning, he also had a great influence in the 17th century, and what I know is that Oughtred invented the slide rule for the first time."

Based on the results of the interview, the classification of student answers can be seen in Table 2.

Table 2.
Student categorization of the interview regarding William Oughtred and his inventions

No	Symbol	Meaning
1	Know Oughtred History	Students have an idea of who William Oughtred was and what his inventions were.
2	Forget Oughtred History	Students have an idea of who William Oughtred was but do not know his invention, and vice versa, students do not know who William Oughtred was but know his inventions.
3	Indifferent to Oughtred History	Students have no idea at all about who William Oughtred is and his inventions.

C. Discussion

The results described above, in order to be used as findings, were adjusted to the relevant theories carried out in the previous studies. Based on the objectives of the study, namely exploring the extent of students' knowledge of mathematician William Oughtred and his inventions, the students' knowledge was categorized into 3 including Know History Oughtred, Forget History Oughtred, and Indifferent to History Oughtred. For this reason, the researcher explained the findings and compared them with previous studies.

1. Know History Oughtred

The findings regarding Oughtred's know history are those students who acknowledged the history of mathematician William Oughtred and his inventions. In this case, it implied that the students considered history important to learn to train critical thinking skills, and if there are problems regarding any form of history, students, as the next generation of the nation, memorize and recognize the issue that may contribute to the progress of the nation. Thus history will not be extinct and forgotten.

This result was in line with (Darsono, 2019): By learning history, students could improve their ability to think chronologically and gain an understanding of the past to interpret the process of development and the change of the society and socio-cultural diversity in order to find and develop national identity in social life. This is in accordance with (Septianingsih, 2016): Learning history aimed to make students aware of the diversity in each environment and the differences in perspectives of the

past to interpret the present and improve thinking patterns to live in the future.

A study by (Hermanto, 2016): History learning was a way for each student to think more perceptively, to be able to interpret the meaning or value of each event that occurred, not just remembering figures, facts, and years of events.

Learning history does not only focus on factual knowledge, but also aims to develop critical and reflective thinking skills in students. In this context, historical learning was considered as a tool to help students understand the meaning and value of each event, such as the history of William Oughtred inventing the slide rule in mathematics.

A study by (Rulianto, 2019) supported the finding: Learning history was not merely learning folklore such as myths and legends that were deliberately created for a specific purpose. Studying history was very useful for answering human curiosity.

For example, the history of Oughtred's invention of the slide rule showed how knowledge and innovation evolved over time, and how the use of such tools had influenced various fields including mathematics, astronomy, engineering and so on. In this sense, learning history not only satisfied human curiosity, but also provided an understanding of the history of science and technology that was very beneficial for human development in the future.

A study of (Mirhan, 2014) support this argument: History is usually associated with the term civilization, and also culture. Thus, history is a science to find, reveal and know the cultural values and meanings contained in past events. History played an important

role. through history, by remembering the past we will be able to build a better future. For example, the logarithm developed by Oughtred in the 17th century had a huge impact on modern mathematics and technology. However, without studying history, we may not understand how important the discovery was and how it may affect technological advancements in the future.

To support this finding, (Saputro, 2022) implied : Studying history is a form of strengthening love for the country and nation and becoming a good citizen. History learning can provide benefits and meaning in life if it can learn it seriously and be able to develop its insights in making decisions. Even in life this historical value can shape and change students who usually do not appreciate time to be able to appreciate time, because history cannot be separated from time. History also helps foster and strengthen the nation's character. It was in line with (Amirullah, 2017): History as a science is indeed very useful in human life, especially in fostering the nation's morals.

Although Oughtred's history did not directly address the morals of the nation, it provided some insight and broader understanding of human history and humanity and might provide inspiration for the nation, such as Oughtred's tenacity and perseverance to find useful tools in the development of mathematics.

2. Forget History Oughtred

The findings regarding Oughtred's forgotten history depicted those students who were forgetting the history of Oughtred and his inventions, but with a little assistance, students were able to recall the history. This was in line with (Nofindra,

2019): Memory gives humans the ability to remember things. This illustrates that humans are able to capture and reawaken the information they have experienced. The things he has experienced are not completely lost, but remain stored in his memory and at a certain time if needed can be remembered (called) again.

This finding was supported by (Firdaus & Rizki, 2021): Millennials in today's global era think very realistically, while history is a past event, which according to them is past and finished. As a young generation, they should have an understanding of history. By understanding history, the younger generation can know their history and origins. "Do not forget history" is what Bung Karno used to say that we know until now. In general, people think that history lessons are unimportant. Memorization, tasks plus teaching educators who do not utilize media to attract students' interest in learning history. History is defined not only as a series of events but a circle of events that unfolds in a coil of ideas.

However, the history of mathematician Oughtred was necessary and important to learn because his invention help us understand more complex mathematical concepts. The introduction of slide rule to the students might improve math problem-solving skills, as well as provide a better understanding of the history of technological and mathematical development (Lai & Wiesenfeld, 2011).

Another study that also supported these findings is (Lempas et al., 2019): Currently, the younger generation might run away from and left history. The younger generation is more fond of exploring the outside world by utilizing the gadgets they

have, thus making the younger generation lost interest in history.

Another study supporting this finding is (Syahputra et al., 2020): History lessons should be able to support students to understand and explain the various historical phenomena studied. However, in Indonesia itself, history learning has been criticized by curriculum experts because it is dominated by memorized teaching materials. Students are led to just remember without realizing efforts to develop high attitudinal intellectual abilities. Therefore, students will quickly forget because it is not accompanied by practice in life.

3. Indifferent to History Oughtred

The findings regarding Indifferent to history Oughtred illustrated that students did not foster their knowledge of the history of Oughtred and his inventions because they consider history to be unimportant and boring. This finding is relevant to research (Arieana, 2018): In the midst of such historical thinking conversations, we are directed to another situation, namely the lack of student interest in history. This phenomenon can be seen in the history learning process at school. At school, students view history as a bored and uninteresting subject because they have to memorize past events, names of kingdoms, and years of events. the role of history has long been ignored in this country. This is also expressed by (Afrianti et al., 2018) : history lessons are now considered as something boring, because they are stuck in the habit of memorizing. so that many students consider that history lessons do not bring

benefits because the study of the past is far from the social environment of students.

Another study that supported these findings are (Efendi et al., 2021): Gen Z as digital natives are more dependent on speed in receiving information, so they have less tolerance for things that are slow, jump from one task to another, multitask, and understand images more easily than text.

Other studies that also support these findings were (Amboro, 2020): So far, history has always been synonymous with dense and even boring material. The reason is that starting from the use of inappropriate teaching methods to subjects that are too formal and rigid, which causes history to be uninteresting. In accordance with the statement (Asmara, 2019): The problem today is that history is considered unimportant by some students, because it only struggles with the past.

Learning history is often not interpreted as an effort to foster a national attitude, especially since history is considered less exciting and monotonous.

Another study that support these findings was (Suswandari, 2016): In the current era of global culture, history is no longer considered a useful lesson in education, because the global world is dominated by sophisticated technology.

The categorization of students in recognizing historical figures in the findings of this study was quite interesting to study because it provided information to educators regarding students' weaknesses of the history of mathematics. The categorization of the classification of students had been widely discussed in the research. Such as Harisman et al., (2021)

who obtained 4 categories of students in solving mathematical problems, namely naive, routine, semi-sophisticated, and sophisticated. Furthermore, in research Harisman et al., (2023) have also categorized the classification of students in solving mathematical literacy problems. The student category in this finding explained the level of students called moderate mathematical literacy, Power Stone category, and high literacy ability. There were few who investigated how the classification of students in understanding the history of mathematics, especially the basic inventors of science in the development of theorems and definitions that we use in modern days.

IV. CONCLUSION

William Oughtred was a well-known English mathematician who contributed to mathematics. Among Oughtred's inventions, the slide rule, the sine rule and the tangent rule and many more of his inventions and contributions were prominent to the mathematics development. However, in today's millennial era, history is starting to be forgotten as seen from the number of students who did not recognize the mathematician, Oughtred, and his inventions in this paper. Therefore, students should learn and understand more about history, especially mathematicians because if there were no such experts, there would not be an invention or formula that is useful to us today.

Humans and history have a close relationship. Without history, humans as living beings deserve to have their existence and activities questioned. Likewise, history

would not exist without human's intervention as it is an event resulting from human actions.

The results illustrated that the students recognized William Oughtred and his inventions to certain extents. From the diverse responses that the participants gave, the study found three categories of students regarding their knowledge regarding the issue. The three categories were, Know History Oughtred, Forget History Oughtred, and Indifferent to History Oughtred.

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