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Place Value in Primary Sources Activity

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# Place Value in Primary Sources

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Objective: Examine the use of place-value in the Hindu-Arabic numeration system from a historical viewpoint by looking at primary sources.

Prerequisites: Basic familiarity with the Hindu-Arabic base-ten place-value numeration system and Roman numerals I (one), V (five), X (ten), L (fifty), C (100), D (500), M (1000).

Prior to the 13th century, Europeans used Roman numerals when they needed to write down numbers. Leonardo of Pisa, also known as Fibonacci, introduced the Hindu-Arabic numeral system to Europe in 1202 in his book *Liber Abacci*. They appear on page 2 at the beginning of the first chapter, where he writes
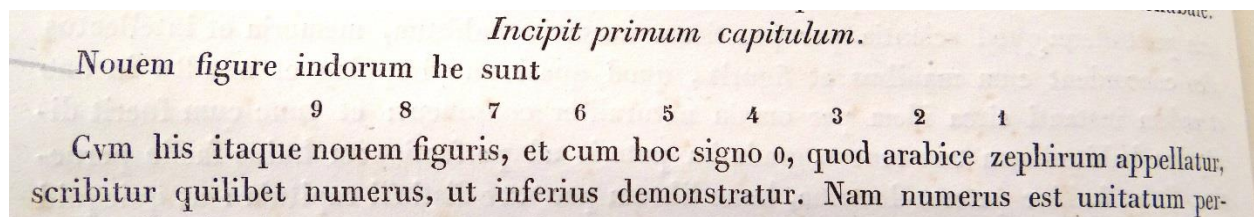
Translated into English:

These are the nine figures of the Indians

$$9 \quad 8 \quad 7 \quad 6 \quad 5 \quad 4 \quad 3 \quad 2 \quad 1$$

And so, together with these nine figures, and with this symbol 0, which is called zephyr by the Arabs, any number can be written, which is demonstrated below.

Fibonacci then goes on to explain place value, since this is a new concept to someone only familiar with the Roman numeration system, which is mostly additive. His explanation includes discussing the value of the different positions from right to left: units or ones, tens, hundreds, thousands, and on "in infinitum". Following the place value explanation, there is a table containing examples of Roman numerals written with Hindu-Arabic numerals.
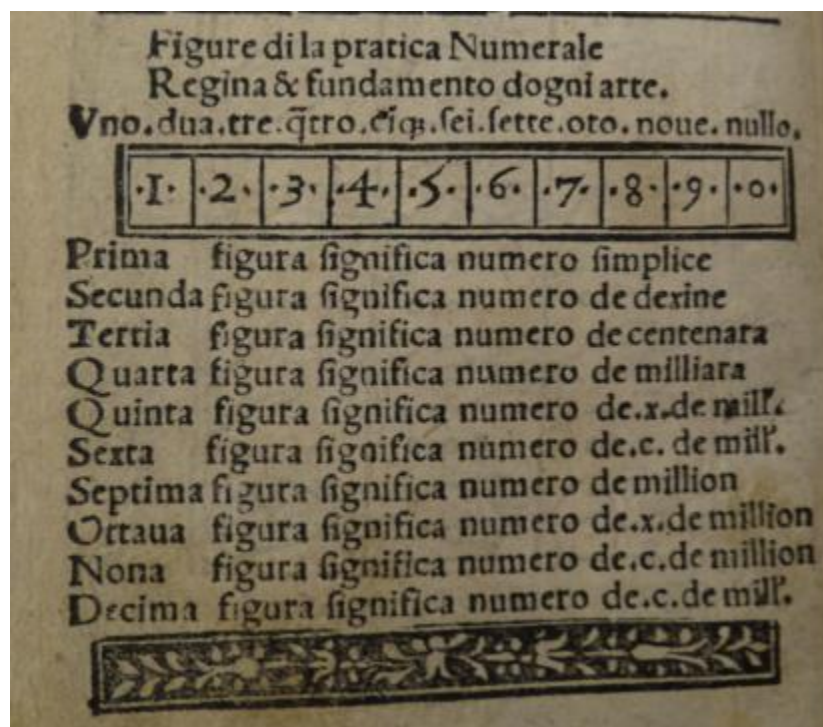
TASK 1: A. Fill in the missing blanks in the table below from Fibonacci's *Liber Abbaci*.

M .ı	MMxxııı		MMMxx	M MMMMᴅᴄ			Mccxxxıııı	MMMMcccxxı
1001		3 0 2 2			3 0 0 0	1 1 1 1		

B. What do you notice about the length of the written numerals in the examples in the two different numeration systems?

Later authors of arithmetic books followed Fibonacci's lead, starting with an explanation of the Hindu-Arabic place value system and then providing several examples. The picture below is from an Italian book called *Libro d'Abaco* by Tagliente, first published in 1515.

Figure di la pratica Numerale
Regina & fundamento dogni arte.
Vno.dua.tre.qtro.ciq.fei.fette.oto.noue.nullo.

·I·	·2·	·3·	·4·	·5·	·6·	·7·	·8·	·9·	·0·

Prima   figura fignifica numero fimplice
Secunda figura fignifica numero de dexine
Tertia   figura fignifica numero de centenara
Quarta figura fignifica numero de milliara
Quinta figura fignifica numero de.x.de mill.
Sexta   figura fignifica numero de.c. de mill.
Septima figura fignifica numero de million
Ottaua figura fignifica numero de.x.de million
Nona   figura fignifica numero de.c.de million
Decima figura fignifica numero de.c.de mill.

Next Tagliente has a full page of examples of numbers written using the Hindu-Arabic numeral system. There are two columns. The left column contains the Hindu-Arabic numerals and the right column has the numbers written out in Italian.

TASK 2: A. Complete the middle column of the following table. On the left are 24 Hindu-Arabic numerals in the order they were given on leaf 5. (Even by the early 16th century, not all books had page numbers.) The right column has the Italian number names scrambled. Fill in the middle column with the correct Hindu-Arabic numeral, from the choices on the left, to match the corresponding Italian name on the left.

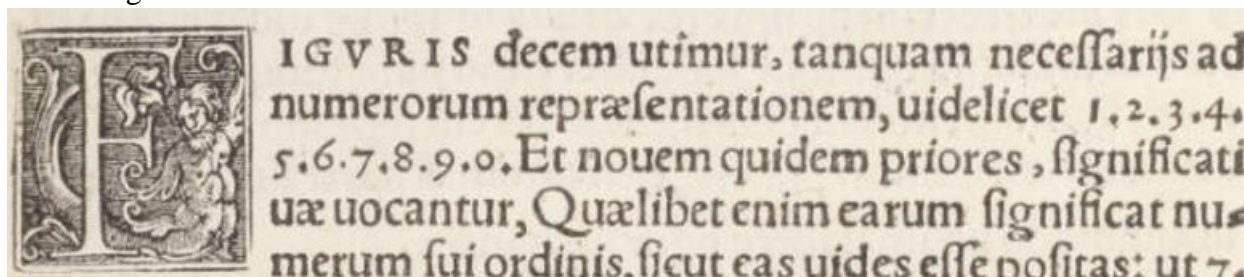| Possibilities to use in the middle column	Fill in the correct Hindu-Arabic numeral to match the name on the right	Numerals in Italian
10		cento
14		cíꝗ millia.8.céto.89
16		diexe
34		diexe millia
77		doe millia treséto.57
99		ducento trenta vno
100		4.millió.958. mi.360
231		475.millió.789 mi.124.
391		mille
658		nonanta noue
999		noue céto nonáta .9.
1000		noue mi. 9.cento.99.
2357		18.millia trecento.2.
3179		otto millia.7.céto.7.
5889		quatordexe
633		fedexe
8707		fei céto cinquáta ott
9999		feranta fette
10000		fie millia trecento.33.
18302		347.millia.916.
347916		trea millia cento.79.
4958360		trecento nonanta vn

23895438		trenta quatro
475789124		23.mill.õ.895.mi 438

B. Did you notice any patterns? Abbreviations? What does the word "mille" or "millia" mean? Any questions or comments?

You may have noticed that a tilde ~ was sometimes put over a vowel in the Italian words above as an abbreviation for the letter "n" to follow. For example, *cẽto* was used for *cento* (for 100), *trecẽto* was used for *trecento* (for 300), and *milliõ* for *million*.

Although Tagliente used the word million as we do today for $1,000,000 = 10^6$, not everyone in the 16th century did. Below are images from *Arithmetica Integra* by Michael Stifel, a friend of Martin Luther. This work was published in 1544 in Latin. He starts out on page 1 mentioning the ten digits.

IGVRIS decem utimur, tanquam necessarijs ad numerorum repræsentationem, uidelicet 1.2.3.4. 5.6.7.8.9.0. Et nouem quidem priores, significati uæ uocantur, Quælibet enim earum significat nu- merum sui ordinis. sicut eas uides esse positas: ut 7.

Then he gives a brief explanation of place value using the example 324, before the following example.

2 3 2 9 0 8 9 5 6 2 8 0 0,

Stifel explains that while the 2 is the last of the 13 digits (figura), it is the first when it comes to saying the number out loud. Then he goes on to give the entire enunciation of the number.

Primum itacʒ membrum enunciandum, eſt 2. facitʹcʒ duo mil
lia, millies, millies, millies .

Sequitur 329. facitʹcʒ trecenta uiginti nouem millia, millies,
millies.

Sequitur 089. facitʹcʒ octuaginta nouem millia, millies.

Sequitur 562. facitʹcʒ quingenta ſexaginta duo millia.

Sequitur demum primū membrum, quod in enunciatione ul
timum eſt, uidelicet 800. facitʹcʒ octingenta.

The first sentence says to say the leading 2 as "two thousand, thousands, thousands, thousands."
The second sentence says that the 329 which follows is enunciated as "three hundred twenty-nine
thousand, thousands, thousands." For the third sentence, the 089 which comes next is read as
"eighty-nine thousand, thousands." The next sentence is left as part of Task 3. The last sentence
says that finally the first member follows, which is read last, is clearly 800, and is "eight
hundred."

Task 3: A. Translate the fourth sentence from the Stifel excerpt above.

B. Write out in words how you would enunciate Stifel's 13 digit example: 2,329,089,562,800