Remarks on Mathematical Terminology in Medieval Latin: Greek and Arabic Influences

The development of mathematical terminology in the Latin Middle Ages has not yet been systematically investigated; there is in print no report on the whole field, only three general articles [1] and occasional specialized information on a special text. Accordingly, my talk is based on my own work on mathematical texts of this time. They show that there were two different traditions. One of these came from Greek mathematical writings which were known in Latin by translations and reworkings made in Roman times and late antiquity – they were a formative influence on medieval culture. The second tradition begins with the translations from Arabic into Latin in the 12th century: thereby a large number of Greek writings became known and at the same time Indian and Arabic mathematics, which in part belonged to the same tradition. In the following I should like to describe these traditions and to characterize their principal trends with the help of a few examples.

1. The Greek-Roman tradition

Before the 12th century mathematical knowledge in the Western Middle Ages depended on what was transmitted in Latin from antiquity, i.e. the mathematics of the Romans. In what did this Roman mathematics consist? We can summarize it under four headings:

a) Greek mathematical writings which were translated into Latin. Perhaps we should remark that a typical educated Roman of the classical period would normally read the Greek mathematical classics in the original, but it seems likely that in late antiquity these classics were seldom read in Greek: it is no surprise that translations were made at the end of the 5th century. But we know only two translations, both by Boethius (d. 524/525), the "Elements" of Euclid and the Arithmetic of Nicomachus. Boethius' "Arithmetica", which is essentially a translation of Nicomachus, was very well known during the whole of

[1] Kouskoff 1981, Allard 1990 and L'Huillier 1994.

the Middle Ages. As for Euclid, we may doubtless assume that Boethius translated all 13 or 15 books. But in the 9th century, the time of the earliest manuscripts, there survived only most of the propositions of books 1-4, the definitions of books 1, 3, 4 and 5, and proofs of the first three propositions of book 1. Through Boethius' "Arithmetica" the Greek theory of numbers was known in the Middle Ages. Here no practical procedure for calculation is meant, but rather theoretical considerations of the classification of integers according to divisibility and the classification and study of ratios of numbers. Quite distinct is the theory of proportions in book 5 of the "Elements". In the first four books the plane geometry of the line and the circle is treated.

b) The writings of the Roman surveyors (*agrimensores*). These writings are in the tradition of practical Greek mathematics, of which an example is the work of Hero of Alexandria (1st c. AD). They were collected in late antiquity into a "corpus", which was enlarged during the early Middle Ages in several stages. In this tradition the mathematics necessary for surveyors was transmitted – for example the procedure of designing new towns with their roads in north-south and west-east directions – together with more theoretical mathematical considerations, such as the definitions of geometrical entities. Non-mathematical matters were also included. The largest mathematical work in this tradition written in antiquity was the practical geometry of Balbus (ca. 100 AD).

c) Latin encyclopaedias, of late antiquity, of the so-called "artes liberales". Of this seven-fold division of knowledge, which was the educational norm from the 1st century BC, two elements were arithmetic and geometry. Accordingly there were books or sections of books specially devoted to arithmetic, geometry or both. The most important books of this kind were by Varro (1st c. BC; lost), Calcidius (4th c. ?), Macrobius (ca. 400), Martianus Capella (5th c.), Cassiodorus (d. 575) and Isidore of Seville (d. 636).

d) There were also the practical mathematical considerations of everyday life. We find mathematical ideas and terms in Latin works which are not specifically mathematical.

Accordingly, the mathematical *termini technici* that the early Middle Ages inherited from the Roman sources came partly from theoretical writings and partly from practical mathematics, both in written form and from oral tradition. Therefore there was no homogeneous mathematical language in the Latin West before the translations from the Arabic. I should like to illustrate this with a few examples.

Through Boethius' "Arithmetica" all important *termini technici* for the different kinds of integers were known in the Middle Ages[2] and the *termini technici* for the different kinds of ratios[3]. These terms were used throughout the

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[2] E.g. *numerus naturalis, numerus primus et incompositus, numeri ad se invicem primi, numerus perfectus, numerus superfluus.*

[3] *proportio multiplex, proportio superparticularis, proportio superpartiens.*

Middle Ages, both in strictly arithmetical treatises and in related literature. In this category there are writings on music theory and on "rithmomachia", a mathematical game invented in the 11th century and extremely popular till the 17th century. The 13th-century writer Jordanus de Nemore included much of the Boethian theory, and with it the terminology, in his "De arithmetica".

From Boethius' translation of Euclid's "Elements" the terms for elementary geometrical ideas became known – well before the translations from the Arabic. For instance, from book 1 of the "Elements" the terms *punctum, linea, superficies, angulus, circulus* – so far, perhaps, the terms are of normal everyday usage –, the various *rectilineae figurae* and related terms became known. In this category belong the various kinds of angles [4], of triangles [5] and of quadrilaterals [6]. Some of these terms are the Latin equivalents of the Greek terms, but in other cases the Greek terms were simply taken over. Sometimes the transcribed Greek terms appear with Latin explanations – this goes not only with *trapezia*, but also, for instance, with *parallelae, id est alternae, rectae lineae* (I def.23), with *cynas etnyas* [in classical Greek: κοιναὶ ἔννοιαι], *id est communes animi conceptiones* and also *aethimata, id est petitiones* (as explanation for the axioms and postulates). There is a curiosity in the definition of a general quadrilateral, which runs: *Praeter haec autem omnes quadrilaterae figurae trapezia calontae, id est mensulae nominantur* [7]. The Greek text runs: τραπέζια καλείσθω. From the Latin wording it seems that its Greek source had τραπέζια καλοῦνται (instead of καλεῖται) and that not only the mathematical term, but also the verb was transliterated into Latin.

Now some remarks about geometrical terms taken from practical geometry. I restrict myself to examples from Balbus' "Expositio et ratio omnium formarum", which belongs to the oldest redaction of the "Corpus agrimensorum". It was written about 100 AD and is the oldest surviving Latin treatise on the elements of geometry [8]. Balbus wrote the book to explain to professional surveyors everything that they needed. The work begins with a list of units of measure. Then he explains the elementary geometrical terms: point, line, surface, solid, angle, figure. There are similarities to Euclid's definitions, but the text is more practically oriented. For instance, Balbus recognizes three sorts of line: *rectum, circumferens, flexuosum* [9]. *Circumferens* refers to the circumference of a circle and *flexuosus* to any curved line. Balbus' word for "point" is not *punctum* or *punctus*, but *signum*, which has a more physical connotation [10]. Again, the "boundary" is not defined as the extremity of something, as in

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4 *acutus angulus*; *rectus angulus*; *obtusus angulus*.

5 *aequilaterus triangulus*; *orthogonius triangulus*; *amblygonius triangulus*.

6 *quadratum*; *parte altera longius* = rectangle; *rhombos* = rhombus; *rhomboides* = parallelogramm; *trapezia id est mensulae* = the other quadrilaterals.

7 FOLKERTS 1970, p. 182, l.48f.

8 Edited by LACHMANN 1848, p. 91-107.

9 LACHMANN 1848, p. 99, 3f.

10 LACHMANN 1848, p. 97, 14f.: *Omnis autem mensurarum observatio et oritur et desinit signo. Signum est cuius pars nulla est.* For the history of the terms *punctum* and *signum* see KOUSKOFF 1984.

Boethius' Euclid [11], but legalistically: as far as the right of possession is conceded to someone [12]. A surface is not *superficies*, but *summitas* [13]. In Euclid a figure is *figura*, but in Balbus it is *forma* [14]. Euclid distinguished the circle (*circulus*) from the rectilinear figures (*rectilineae figurae*) – the latter being divided into trilateral, quadrilateral and many-sided figures (*trilatera*, *quadrilatera*, *multilatera* [15]); but Balbus distinguishes five sorts of figures, according to the type of line that bounds them (*flexuosae*, *circumferentes*, or *rectae*) [16].

Balbus' geometrical terminology is similar to that of other mathematical writings of the Corpus agrimensorum, especially the anonymous "Liber podismi" [17] and the voluminous treatise of Epaphroditus and Vitruvius Rufus [18]. Numerous technical terms in these works, which were written at the latest in the second century AD, clearly show their Greek origin: the types of triangle (*amblygonium*, *orthogonium*, *oxygonium*), special terms for the sides of triangles (*cathetus*, *hypotenusa*, and also *hypotenusa maior* or *minor* in an obtuse-angled triangle), *embadum* (area). Other terms are: *perpendicularis* (perpendicular, altitude) and *eiectura* (the line segment outside an obtuse-angled triangle between the point of the obtuse angle and the foot of the perpendicular). A curiosity is the word *aera* in Epaphroditus' work, which means "a given number from which a calculation begins" [19].

Now for the encyclopedias of late antiquity and the early Middle Ages. In general these contain knowledge from numerous sources, collected together uncritically. It is no wonder that the mathematical technical terms were partly collected from theoretical sources and partly from practical writings. I should like to give special mention to Martianus Capella's "De nuptiis Philologiae et Mercurii", which gives more space to mathematical *termini technici* than the other encyclopedias. Every book is devoted to one liberal art, but Book 6, on geometry, is largely about geography. At the end of the book there is a long section on geometrical terms, with explanations of their meanings [20]. We find many terms of plane geometry that are similar to those in the first book of Euclid's "Element". On the other hand the three sorts of angles are not *rectus*, *acutus*, *obtusus*, but *iustus*, *angustus*, *latus* [21]. For lines he makes a distinction

[11] Euclid I def.13: *Terminus vero est, quod cuiusque est finis* (Folkerts 1970, p. 179, 18).

[12] *Extremitas est, quousque uni cuique possidendi ius concessum est* (Lachmann 1848, p. 98, 3).

[13] Euclid: *Superficies vero, quod longitudinem ac latitudinem solas habet* (Folkerts 1970, p. 177, 5); Balbus: *Summitas est secundum geometricam appellationem quae longitudinem et latitudinem tantummodo habet* (Lachmann 1848, p. 99, 11f.).

[14] Euclid: *Figura est, quod sub aliquo vel aliquibus terminis continetur* (Folkerts 1970, p. 179, 17); Balbus: *Forma est quae sub aliquo aut aliquibus finibus continetur* (Lachmann 1848, p. 104, 1f.).

[15] Folkerts 1970, p. 179-181.

[16] Lachmann 1848, p. 104, 3-7.

[17] Ed. Bubnov 1899, p. 510-516.

[18] Ed. Bubnov 1899, p. 516-551.

[19] Bubnov 1899, p. 532, 10 and elsewhere. For the meaning of this term see Bubnov 1899, p. 534f., note 27.

[20] Dick 1925, p. 351-362.

[21] Dick 1925, p. 358, 8f.

of those that are straight (εὐθεῖαι), circular (κυκλικαί), spiral-shaped (ἑλικοειδεῖς) or curved (καμπύλαι)[22]. We note that all names are Greek. Martianus even mentions the various sorts of irrationals which we find in Euclid, Book 10[23]. He takes over Euclid's terms – in Greek, no attempt being made to find Latin equivalents. He tries to explain the simplest irrationals, but a reader would not understand the meanings of the words if he had no other source[24]. It is noteworthy that Martianus everywhere gives Greek terms in Greek letters. Of course, the scribes of the numerous extant manuscripts did not understand Greek and most of the words, which the scribes misinterpreted as Latin, are totally corrupt.

Of special importance for the mathematics of the Middle Ages are the "Geometry" written by Gerbert of Aurillac about 980[25] and a text often accompanying it in the manuscripts. The second text, which is anonymous, is generally called "Geometria incerti auctoris"[26]. It is little older than Gerbert's work – it was written in the 9th or 10th century –, but Gerbert's "Geometry" is more important for our purpose, because Gerbert treats the fundamentals of geometry, while the "Geometria incerti auctoris" is in the tradition of practical mathematics: calculations about triangles, quadrilaterals and polygons, the circle and simple solids and also the determination of the breadth of rivers, the height of mountains or of towers and the depth of wells.

Gerbert brought together the knowledge of his time in a systematic way. He treats: the terms of plane and solid geometry; units of weights and measures; the various plane figures, above all the varieties of triangles and rules for determining the sides and areas. Gerbert knew the works of Boethius and those of the Boethius tradition, the writings of the *agrimensores* and the encyclopedias. In most cases it is plain what sources he had used. Some terms, and indeed whole sentences, are taken from Euclid and he cites Boethius explicitly. Gerbert often gives the Greek as well as the Latin terms and it is very likely that he got the Greek words from Martianus Capella[27]. Some examples of his critical compilation:

> Punctum est parvissimum et indivisibile signum, quod graece symion dicitur[28] (Euclid; agrimensores)

[22] Dick 1925, p. 353, 3-6.

[23] Dick 1925, p. 359f.

[24] E.g. p. 359, 10-14: *Lineas autem, quae sibi consentiunt,* συμμέτρους *dicimus, quae non consentiunt,* ἀσυμμέτρους. *Et non mensura sola, sed et potentia* συμμέτρους *facit, et dicuntur* δυνάμει σύμμετροι; *in mensura autem pares* μήκει σύμμετροι *appellantur.*

[25] Ed. Bubnov 1899, p. 48-97.

[26] Edited in Bubnov 1899, p. 317-365.

[27] Gerbert mentions the following Greek terms (in brackets the Latin equivalents given by Gerbert): *stereon* (*solidum corpus*); *epiphania* (*superficies*); *gramma* (*linea*); *symium* (*punctum*); *euthyae* (*figurae planae*); *euthygrammae, cyclicae, elycoydae, campylogrammae figurae*; *micton*; *embadum* (*area*); *euthygrammi* (*rectilinei anguli*); *parallelae* (*aeque distantes lineae*); *orthogonius, amblygonius, oxygonius triangulus*; *isopleuros, isosceles, scalenos triangulus*; *basis*; *coraustus*; *cathetus* (*perpendicularis*); *hypotenusa* (*podismus*). For the history of the term *podismus* see Bubnov 1899, p. 78, note 16, with Addenda on p. 557.

[28] Bubnov 1899, p. 54, 4f.

Solidum corpus est quidquid tribus intervallis seu dimensionibus porrigitur, id est quidquid longitudine, latitudine altitudineque distenditur ... Hoc autem graece stereon dicitur [29] (Macrobius; Martianus Capella)

Superficiei vero extremitates sive terminus linea, seu graece gramma est [30] (Euclid; Balbus; Macrobius)

Figurae planae ... aut curvis seu circumferentibus lineis, quas Graeci cyclicas sive elycoydas sive campellas vocant, includuntur, et rotundae sive oblongae sunt, et campylogrammae nominantur [31] (Martianus Capella).

Despite his heterogeneous sources Gerbert succeeded in writing a largely consistent and comprehensible compilation. I only know one example of an incorrect explanation of a term: Gerbert identified an acute angle with an inner angle of a triangle and an obtuse angle with an external angle [32]. This formulation raised discussions among scholars in Lorraine at the beginning of the 11th century [33].

2. Technical terms from the translations from Arabic

The geometrical terminology that we find in Gerbert and the so-called "Geometria incerti auctoris" was used during the entire Middle Ages and even in the early modern period. But the number of the geometrical technical terms increased enormously in the 12th century, when through the translations from the Arabic many hitherto unknown texts became available in Latin. Familiar mathematical areas acquired new terms and whole new mathematical subjects became known, and these of course required their own technical terms. Among the latter we may name conic sections, spherical geometry, trigonometry, algebra and the new arithmetic based upon the Hindu-Arabic place value system.

The problems that the translators of mathematical texts had to solve were in principle the same as those faced by the translators of astronomical, mechanical, philosophical, medical and other scientific texts. Since Professor Kunitzsch will outline the formation of terminology in astronomical writings, I may here be brief. Accordingly I restrict myself to some general remarks and a couple of examples.

For the new arithmetic there were few usable terms available in the Latin tradition of antiquity and the early Middle Ages. There were, of course, expressions for the four rules of arithmetic: these could be found in Boethius, in writ-

[29] Bubnov 1899, p. 52, 13-17.

[30] Bubnov 1899, p. 53, 6f.

[31] Bubnov 1899, p. 64, 15 - 65, 3.

[32] *... acuti anguli interiores, hebetes vero exteriores ad comparationem scilicet recti anguli solent appellari* (Bubnov 1899, p. 68, 12-14).

[33] The so-called "angle dispute", which appears in the correspondance, of about 1025, between Radulph of Liège and Ragimbold of Cologne; see Tannery/Clerval 1901.

ings of the *agrimensores* and also in non-mathematical writings [34]. There were also special arithmetical terms used for the so-called Gerbert abacus and its operations. This means of calculation was used between the end of the 10th century and the 12th century in monasteries. In writings about this abacus calculation not only with integers was described, but also with Roman fractions, which were based upon the division of the *as* into twelve parts [35]. This abacus and calculation with it became obsolete in the 12th century, when the decimal place-value system, the Hindu-Arabic numerals and written calculation with them became available in translations from the Arabic; but a few of its special terms were taken over into the literature of the new arithmetic. The Roman fractions also became obsolete and were replaced by common fractions and sexagesimal fractions. The new arithmetic needed new terms in all its branches. These terms were supplied in the translation of al-Khwārizmī's "Arithmetic" [36]. It should be mentioned that the names for the Hindu-Arabic numerals used in the tracts on the Gerbert abacus were not taken over for the new arithmetic [37].

To illustrate how the Arabic mathematical terms were turned into Latin in these translations, I give here the example of the various quadrilaterals, which are defined in Euclid I def. 22. I begin with the terms in Greek and in the Arabic translation by Isḥāq-Thābit (which is transmitted in all the surviving Arabic manuscripts) and then present the terms found in the most important Latin versions.

square:

τετράγωνον

*murabba*ᶜ (= "quadrangle")

quadratum (Boethius [38]; Adelard of Bath [39]; Hermann of Carinthia [40]; Gerard of Cremona, Euclid [41]; Gerard of Cremona, Nayrīzī [42]; Robert of Chester [43]; John of Tinemue [44]; Campanus of Novara [45])

tetragonum (Greek-Latin translation [46])

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[34] E.g. *addere, iungere, aggregare* (to add); *demere, diminuere, subtrahere* (to subtract); *multiplicare, ducere* (to multiply); *summa* (product); *dividere* (to divide).

[35] All of these terms can be found in the "Index rerum et verborum" printed at the end of Bubnov's edition of Gerbert's mathematical writings (Bubnov 1899, p. 579-612), because Bubnov edited not only Gerbert's treatise on the abacus, but also many other works in the Gerbert tradition.

[36] For a glossary of the Latin technical terms in this work, see Folkerts 1997, p. 193-204; for the technical terms in the derivative texts, see Allard 1990.

[37] *igin, andras, ormis, arbas, quimas, calctis, zenis, temenias, celentis, sipos*. For the history of these names, see Folkerts 2003.

[38] Folkerts 1970, p. 181, 39.

[39] Busard 1983a, p. 32, 48.

[40] Busard 1968, p. 10.

[41] Busard 1983b, col. 2, 53.

[42] Tummers 1994, p. 22, 8.

[43] Busard/Folkerts 1992, p. 114, 43.

[44] Busard 2001, p. 34, 168.

[45] Busard, in print.

[46] Busard 1987, p. 28, 4.

rectangle:
ἑτερόμηκες
al-mukhtalif al-ṭūlayn (= "that with two different lenghts")
parte altera longius (Boethius [47])
quadratum longum (Adelard [48])
tetragonus longus (Hermann [49]; Robert of Chester [50]; Gerard, Nayrīzī [51]; John of Tinemue [52]; Campanus [53])
(figura) duarum diversarum longitudinum (Gerard, Euclid [54])
eteromikes (Greek-Latin translation [55])

rhombus:
ῥόμβος
al-muᶜayyan (= "certain, determined")
rhombos (Boethius [56])
rombus (Gerard, Euclid [57]; Gerard, Nayrīzī [58])
rombos (Greek-Latin translation [59])
elmuain (Adelard [60]; John of Tinemue [61])
elmuaim, quam nos rumbum dicimus (Hermann [62])
elmuhain (Robert of Chester [63])
elmuahym (Campanus [64])

parallelogramm:
ῥομβοειδές
al-shabīh bi-l-muᶜayyan (= "similar to the *muᶜayyan*")
rhomboides (Boethius [65])
romboides (Greek-Latin translation [66])
simile elmuain (Adelard [67]; John of Tinemue [68])

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47 FOLKERTS 1970, p. 181, 40.
48 BUSARD 1983a, p. 32, 49.
49 BUSARD 1968, p. 10.
50 BUSARD/FOLKERTS 1992, p. 114, 44.
51 TUMMERS 1994, p. 22, 9.
52 BUSARD 2001, p. 34, 169.
53 BUSARD, in print.
54 BUSARD 1983b, col.2, 54f.
55 BUSARD 1987, p. 28, 5.
56 FOLKERTS 1970, p. 181, 41.
57 BUSARD 1983b, col. 2, 57.
58 TUMMERS 1994, p. 22, 10.
59 BUSARD 1987, p. 28, 6.
60 BUSARD 1983a, p. 32, 50.
61 BUSARD 2001, p. 34, 170.
62 BUSARD 1968, p. 10.
63 BUSARD/FOLKERTS 1992, p. 114, 45.
64 BUSARD, in print.
65 FOLKERTS 1970, p. 183, 42.
66 BUSARD 1987, p. 28, 7.
67 BUSARD 1983a, p. 32, 53.
68 BUSARD 2001, p. 35, 171.

similis elmuaim (Hermann [69])
similis rombo (Gerard, Euclid [70])
romboides, id est similis rombo (Gerard, Nayrīzī [71])
simile elmuhain (Robert of Chester [72])
similis elmuahym (Campanus [73])

other quadrilateral:
τραπέζιον
al-munḥarif (= "shifted, crooked")
trapezium, id est mensula (Boethius [74])
trapezium (Greek-Latin translation [75])
trapezia (Gerard, Nayrīzī [76])
irregularis (Adelard [77]; Gerard, Euclid [78])
almunharifa id est distorta (Hermann [79])
elmunharifa (Robert of Chester [80]; John of Tinemue [81])
helmuarifa (Campanus [82]).

From this example we can see that there were three possibilities for the translation of a technical term:

– The Arabic term was substituted by the Latin term which the translator knew from the Latin tradition (*al-mu^{c}ayyan -> rombus*)
– The Arabic term was translated literally into Latin (*al-munḥarifa -> irregularis*)
– The Arabic term was transcribed letter by letter (*al-mu^{c}ayyan -> elmuain*).
Sometimes the last method of "translation" was supplemented with an explanation introduced by *id est* (*almunharifa id est distorta*).
It is noteworthy that the terms *elmuahim* and *elmuarifa* also occur in treatises on music [83].

There seems to be no way of telling which of these three methods would be used in any one case. But some translators had certain characteristics. For example, we know that Gerard of Cremona favoured a literal translation and

69 Busard 1968, p. 10.
70 Busard 1983b, col. 2, 57.
71 Tummers 1994, p. 22, 11.
72 Busard/Folkerts 1992, p. 114, 46.
73 Busard, in print.
74 Folkerts 1970, p. 183, 44f.
75 Busard 1987, p. 28, 9.
76 Tummers 1994, p. 22, 15.
77 Busard 1983a, p. 32, 54.
78 Busard 1983b, col. 3, 4.
79 Busard 1968, p. 10.
80 Busard/Folkerts 1992, p. 114, 49.
81 Busard 2001, p. 35, 173.
82 Busard, in print.
83 See Wright 1974 and Burnett 1986.

had relatively few transcriptions of Arabic words. Other translators reproduced whole phrases by transcribing the Arabic into Latin [84].

A warning might be given here against too hasty deductions on the origins of a text by analyzing the terms used. In a 12th-century text on Menelaus' theorem there are many Greek terms, such as *cathetos* (for "perpendicular"), *periferia* (for "arc"), and, above all, *sinzuga* (for "associate"). One might think that it was a translation from Greek. But in fact it is a translation from Arabic. No doubt, the translator was acquainted with the translation of the "Almagest" direct from the Greek [85].

I should like to conclude my talk with two further examples: the term *sinus* and the history of the use of x for the unknown in algebra.

Today's trigonometry goes back to the Indians and uses in principle the same procedures that they had developed for astronomical calculations. Our term *sinus* is derived from the word *jīvā*, which means "chord" in Sanskrit [86]. The Arabs transliterated this word as *j-y-b* and took it over into their technical vocabulary. But there was a genuine Arabic word written in the same form: *jayb* (= "the opening in a garment for the head to be put through; breast"). So it is understandable that the translators from Arabic into Latin understood the Arabic term for "sine" in this way and gave its equivalent not as *chorda*, but as *sinus*. Gerard, for instance, used *sinus* in some of his translations [87]. In other astronomical texts translated from the Arabic we find the transliteration *elgeib* [88] or *alieb* [89]. Clearly the term *sinus* was introduced into Latin from astronomical sources.

Also in algebra the Latin terminology was based on the Arabic, in particular for the terms for the unknown and its powers [90]. The Arabs used the following terms:

for x: *shay'* = "thing"; or *jidhr* = "root"
for x^2: *māl* = "wealth"
for x^3: *kaᶜb* = "cube".

In the Latin translations of the "Algebra" of al-Khwārizmī by Robert of Chester and by Gerard of Cremona we find: *res* (*shay'*), *radix* (*jidhr*), *census*

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[84] As to the Euclid translation from the Arabic by Adelard of Bath and the Latin redaction by Robert of Chester, which is based partially on Adelard's text, there are lists of the Arabic terms available in print: Adelard of Bath: BUSARD 1983a, p. 391-395 (with a list of additional Arabic terms which are to be found in a single manuscript); Robert of Chester: BUSARD 1983a, p. 395f.; BUSARD/FOLKERTS 1992, p. 27.

[85] For this "Grecising translation" see LORCH 2001, p. 33-36 and 405-407.

[86] For the history of the term *sinus*, see TROPFKE 1923, p. 16 and p. 32f.; BRAUNMÜHL 1900, p. 49f.; and, above all, NALLINO 1903, p. 154-156.

[87] E.g. the "Astronomy" of Jābir b. Aflaḥ (see LORCH 1995, items V-VIII); Thābit b. Qurra's treatise on the sector-figure (see the edition of BJÖRNBO 1924, p. 12, last line; p. 13, line 9).

[88] E.g. in the translation of al-Khwārizmī's astronomical tables by Adelard of Bath made, as it seems, in 1126 (SUTER 1914, p. 17 etc.; cf. the "Index", p. 243).

[89] E.g. in Hugo of Santalla's translation of Ibn al-Muṯannā's commentary to the astronomical tables of al-Khwārizmī (ed. MILLÁS VENDRELL 1963).

[90] See TROPFKE 1980, p. 376-378 where further literature is mentioned.

(*māl*)[91]. In other texts, for instance in the translation of Abū Kāmil's "Algebra", we also find *cubus* (*ka*^{c}*b*). From the 13th century on, these terms were generally used in algebraic texts.

As sometimes in Arabic, technical terms in Latin, too, were rendered by the initial letters of the normal terms. There are examples from the end of the 14th century on. Since the middle of the 15th century the abbreviations 𝔯, 𝔷, 𝔠 for *radix*/*res*, *census*, *cubus* were often used in Southern Germany[92]. It is very probable that the sign for *res*/*radix* (an *r* with a flourish indicating an abbreviation) developed into the "German" *x* (𝔵) and this into the Latin letter *x* indicating the unknown.

To sum up: There is no straight-line development of mathematical terminology in the Latin Middle Ages; rather, there are various sources and lines of development. We have too few editions with a complete *Index verborum* to establish many of these lines. Even when the development is clear, we can seldom see any reason why one term survives and another is forgotten, e.g. *substantia* disappeared, but *census* lived on. It is far too early to write a history of mathematical terminology in the Latin West.

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91 Robert of Chester regularly has *substantia* instead of *census*; Gerard favours *census*.

92 See TROPFKE 1980, p. 281.

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