Project proposal: **Didactical Aspects of Multilingual Mathematics**

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The idea for the following project arose from my strong interest in mathematics, linguistics, and didactics. The aim of the project is to investigate mathematical terminology in different languages (Swedish, Polish, English, Dutch and possibly Russian) and analyse the impact of differences between languages on teaching of math in the countries they are spoken. My scientific merits, besides the knowledge of the mentioned languages, are: a Master Degree in mathematics from Nicolaus Copernicus University in Toruń, Poland (1997) and a PhD Degree in mathematics from Uppsala University, Sweden (2009).

Many mathematical terms in European languages come from Latin or Greek. I propose to research the similarities and differences between the mathematical terms in the selected languages and try to measure their linguistic distance from their Greek or Latin predecessors (adapted from Parkvall 2010). In spite of the common (Latin or Greek) origin of mathematical terms in European languages, we sometimes meet surprising differences, and I would like to discuss these differences.

Some of the different mathematical terms are simply translations of the common term, like for example Polish *dwusieczna* is a translation of *bisector* (*dwu-* meaning 'bi-' and *siekać, siec* meaning 'to cut'). The same translation operation happened in case of all the underlined words in the table below (in the Appendix).

Other differences are larger than that, like for example in case of the Dutch word for geometry, m*eetkunde*, is formed from two words: *meten* 'measure' and *kunde* 'knowledge', so one could literally translate it back to 'measureology' or 'metrology', while the common European word *geometry* literally means 'Earth-measury'. Another example is the Dutch word for mathematics, *wiskunde*, which was formed by Simon Stevin in the 17th century, then *wisconst*. The word means 'the knowledge (or: 'the art') of certainty', while the Greek word *máthèma* means 'the knowledge / this what is to be learned / lesson'.

Some home-made mathematical terms are very helpful during the learning process. It is probably hard for Swedish speaking students to remember which one is the *hypotenusa* 'hypotenuse' and which one is the *katet* 'leg'. In English it is not so hard, because of the usage of the term *leg*. In Polish both names are self-explanatory: hypotenuse is called *przeciwprostokątna*, where *przeciw* means 'opposite' and *kąt prosty* means 'right angle', and cathetus (the leg) is called *przyprostokątna* (*przy* means 'at', 'about', 'adjacent').

Another kind of difference is absence of certain terms in some languages, terms which exist in other languages. For example *terrasspunkt*, which in Swedish means a stationary point, i.e., the first derivative in this point is zero, but without a local extremum in this point, seems not to exist as a one-word term in other European languages.

Another source of differences is using different mental pictures while describing mathematical objects. For example the disk (a name probably originating in *discus*) is called in Polish *koło*, which gives an association with the wheel of a car/cart, while in Swedish it is called *cirkelskiva*, which nowadays gives an association to a CD, somewhat earlier maybe with a vinyl record, and earlier than that with a slice of something or maybe with a target. Differences like this will be found, listed and described during this project.

During this project I plan to analyze the evolution of mathematical terms through the ages, look closer at their history and give the time and place of something what could be called national purism in mathematical terminology, thus answer the question who and when introduced the terms in native languages. In Sweden one should name Stiernhjelm (the 17th century) and Swedenborg (the 18th century). In Poland the Polish terms were introduced during the Age of Enlightenment, the 18th century. Even the German language and the Dutch language have a lot of home-made terms, while English terms stayed very close to their Latin or Greek predecessors. I will begin with the terms used at the level up to the first year of the university, thus school mathematics, and I will use the terminology book Kiselman & Mouwitz (2008).

Proposed research problems and questions

1. To perform the comparison of mathematical terms in chosen languages (contrastive analysis).
2. To make a map of dependencies between the languages (on level mathematics) and calculate (if such a calculation is possible) distances between each other and between them and Latin and Greek.
3. When and why did some words get translated into different national languages? Who and why took the initiative to do this? (History of development of mathematical terms.)
4. Performing research in the intersection of multilingualism and didactics of mathematics (by means of interviews, surveys etc; I still have contacts in Polish universities and schools and can arrange such activities without problems):
   (1) Does the translation of Latin and Greek mathematical terms (which is common for example in Polish) provide an advantage in understanding math to children studying in these languages?
   (2) Does the usage of Latin and Greek words (which is common for example in English) make it harder to understand and study maths?
   (3) What can we do to help the children become more familiar with mathematical terminology? Can our multilingual awareness be of any help?

Related activities

1. Translating the terminology book (Kiselman & Mouwitz 2008) into Polish.
2. Organising some courses for native-language (Polish) teachers in Sweden in order to draw their attention to the differences in mathematical terminology between Polish and Swedish.
3. Including other languages to the project, in cooperation with Stockholm University, MND (Jöran Petersson).

Positive outcomes of this project

Though the proposed project is a pure research project, its outcomes can be used to strengthen the understanding for mathematics in Europe. Analysis of mathematical terms, their meaning and origin will lead to publications on different levels (I plan some linguistic publications, but they can be adapted for didactical purposes, both for teachers and for students) which can be used in schools with children of different nationalities.

Main beneficiaries of the project's results would be Polish children living in Sweden or in other EU countries. Normally (in Sweden), they have the opportunity to meet a teacher of their mother tongue once a week, but the reality is that there is no time for discussing mathematics during these lessons. Moreover, mathematics is seldom the subject the teachers of Polish in Sweden studied themselves, so it is not obvious that they are familiar with all mathematical terms at high-school level. Translations of the terminology book into other languages would give the students of foreign origin who live and study in Sweden the opportunity to develop their native-language skills in the domain of mathematics. It would be especially helpful for the children who just moved from their homeland to Sweden.

The translations of the book can also be of great value to students who want to become math teachers and to young, unexperienced teachers of mathematics in Poland.

A good help for Polish children living in for example Sweden would be, besides the translation of the terminology book into Polish, a list of mathematical terms in a form of an alphabetically ordered pairs of words (a term in Polish and its Swedish translation) with the following main order (i.e., primary to the alphabetical order) as follows:

1. All the terms which are the same in both languages, with possible differences in the spelling (e.g., wektor — vector) or pronunciation.
2. The Polish term is an exact translation of the term in Latin or in Greek, while the term in the other language is identical to the Latin or Greek original.
3. Terms in both languages are exact translations of the original term in Latin or Greek.
4. Other cases (with an explanation of the idea of the term-creation in given languages, to make it easy for the children to understand and remember the words).

Lists like this would be developed during the research project, simultaneously with the translation process of the book and the source of the terms (our corpus) will be the book itself. It is, of course, perfectly fine to include new terms, which are absent in the book, but are in common use in the country with the target-language of the translation (example: *inversion* in the Polish version).

Related research

The same kind of research (linguistic and historical analysis of terms, comparison between pairs of languages, making a dictionary and developing various didactical tools) could be performed for medicine (biology, physics, chemistry) and for IT. As far as I know, no such research has been done on mathematical terminology, but a similar research (on legal terminology) has been done by Professor Łucja Biel from the Institute of Applied Linguistics at the University of Warsaw. This is one of the reasons why the cooperation with this institute is of such a great importance.

The following people / organisations declared their interest in this project

1. Professor Christer Kiselman, who is without a doubt one of the most qualified persons in Sweden for mathematical terminology, promised his collaboration in this project. He is not only a professor in mathematics, but is a person with a passion for languages and different cultures. He speaks fluently Swedish, English, French, Esperanto and has a basic knowledge about German, Russian, Persian, Classical Greek, and Yiddish.
2. Lars Mouwitz, Guest Professor at Stockholm University and Södertörns högskola. Languages: Swedish, English, German. Main domains of expertise: didactics of mathematics, philosophy.
3. Professor Ewa Gruszczyńska, Instytut Lingwistyki Stosowanej (Institute of Applied Linguistics, University of Warsaw), Scandinavian Research Centre.
4. Eva Norén, Jöran Petersson, researchers from Stockholm University, Department of Mathematics and Science Education, MND.
5. Professor Maria Zadencka, Stockholm University, Department of Slavic and Baltic Languages, Finnish, Dutch and German, Institute of Slavic Languages.

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Appendix: more examples of differences in mathematical terminology

As mentioned before, the results of the proposed project, besides their linguistics value, could be very helpful for Polish children going to school in Sweden, England, The Netherlands or Belgium. In this appendix I list some additional examples to illustrate this statement.

An angle in Polish has arms (*ramiona*) and a top (*wierzchołek*) and not, as in Swedish, legs (*ben*) and a cusp (*spets*). If an angle measures more than 90 degrees, it is called obtuse, both in English and in Swedish (where the corresponding word is *trubbig*), while in Polish it is called open (*rozwarty*). If an angle is acute (in Swedish *spetsig*), a Polish student knowing just regular, common words in Swedish or in English, would probably rather translate the Polish *ostry* into the English 'sharp' and Swedish 'vass', which would just sound funny to the native speakers in the classroom. And an isosceles triangle, which is called in Polish *trójkąt równoramienny* (triangle with equal 'arms') will be (of course!) called in Swedish *likbent triangle*, a triangle with equal 'legs'! But it will not at all be obvious for a child coming originally from Poland.

The Intercept Theorem, called in Swedish 'Transversalsatsen' is known in Poland as *Thales' theorem* (and it has no other names there!) and there is no other theorem associated with this name in Poland (the one stating that *if an angle is inscribed in a circle in such a way that both interception points of the circle with the sides of this angle lie on the same diameter of the circle, then this angle measures 90 degrees* is just known as one of the consequences of the inscribed angle theorem). A possible hint from the teacher "use Transversalsatsen" can just not at all be helpful for a child from Poland, because he/she will probably not recognise the name.

The same holds for well known identities: $a^2—b^2=(a—b)(a+b)$, $(a+b)^2=a^2+2ab+b^2$ and $(a—b)^2=a^2–2ab+b^2$. In Poland all of them are known under a common name *wzory skróconego mnożenia* 'abbreviated multiplication rules' and sometimes specified as *różnica kwadratów* 'the difference of two squares' or *kwadrat sumy / różnicy* 'the square of a sum / difference', while in Sweden the first one is known as *konjugatregeln* and the next two as *kvadreringsreglerna*. Again, at least this first name in Swedish will be completely unrecognisable for a Polish child, even if he/she already learned the rule in Poland. In this way, the child will kind of lose the possible advantage of having learned something in his home country.

There are many examples like this, for many pairs of languages. It is important to help the children who already have enough difficulties in their life, the difficulties caused be moving to another country. By offering them right help in learning mathematics, we can help them gain some self-confidence in the new place. In this way we can empower them by mathematics.

English	Swedish	Polish	Dutch	Russian
symmetry	symmetri	symetria	symmetrie	simmetrija
function	funktion	funkcja	functie	funkcija
isometry	isometri	izometria	isometrie	izometrija
algebra	algebra	algebra	algebra	algebra
vector	vektor	wektor	vector	vektor
geometry	geometri	geometria	*meetkunde*	geometrija

English	Swedish	Polish	Dutch	Russian
mathematics	matematik	matematyka	*wiskunde*	matematika
addition	addition	dodawanie	*optellen*	složenie
subtraction	subtraktion	odejmowanie	aftrekken	vyčitanie/ubavlenie
multiplication	multiplikation	mnożenie	vermenigvuldigen	umnoženie
division	division	dzielenie	delen	delenie
continuous	kontinuerlig	ciągły	continue	nepreryvnyj
differential	differential	różniczka	differentiaal	differencial
integral	integral	całka	integraal	integral
bisector	bisektris	dwusieczna	bissectrice	bissektrisa
distribution	distribution	rozkład	distributie	raspredelenie
polynomial	polynom	wielomian	polynoom/veelterm	mnogočlen
equation	ekvation	równanie	vergelijking	uravnenie
equality	likhet	równość	gelijkheid	ravenstvo
derivative	derivata	pochodna	afgeleide	proizvodnaja
triangel	triangel	trójkąt	driehoek	treugol'nik
square	kvadrat/fyrkant	kwadrat	vierkant/kvadraat	kvadrat
quadrilateral	fyrhörning	czworokąt	vierhoek	četyrechugol'nik
root	rot	*pierwiastek*	wortel	koren'