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From Teaching Numeracy to Developing Mathematical Literacy: Materials and Methods for a CLIL Approach to Mathematics

Britta Viebrock

Abstracts

Dieser Beitrag versteht sich als Ergänzung zu den theoretischen Überlegungen im Beitrag „M² (Multilingual x Mathematical) – Some Considerations on a Content and Language Integrated Learning Approach to Mathematics“ in dieser Ausgabe von *ForumSprache*. Er enthält Unterrichtsmaterial und methodische Überlegungen zum Thema „Prozentrechnung“ und zeigt, wie mithilfe eines fächerübergreifenden, multikontextuellen Ansatzes *mathematical literacy* angebahnt werden kann.

This contribution serves to illustrate the theoretical considerations presented in “M² (Multilingual x Mathematical) – Some Considerations on a Content and Language Integrated Learning Approach to Mathematics” in this issue of *ForumSprache*. It provides material and methodical devices for teaching “percentages” and shows how mathematical literacy can be developed by means of a cross-disciplinary approach.

Este artículo ilustra las reflexiones teóricas de “M² (Multilingual x Mathematical) – Some Considerations on a Content and Language Integrated Learning Approach to Mathematics”, aparecido en este número de ForumSprache. Contiene material para la enseñanza y reflexiones metodológicas sobre el tema del “cálculo porcentual”. Además, muestra cómo se podría iniciar la alfabetización matemática a través de un enfoque interdisciplinar y multicontextual.

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Introduction

In a second, more theoretical contribution to this issue of *ForumSprache,* I have shown that there is no reason to believe that the subject mathematics is unsuitable for a CLIL approach. On the contrary, it offers many opportunities for language work and language reflection in the process of developing topics. This present contribution provides additional teaching materials and methodological considerations that try to go beyond teaching plain numeracy and facilitate the development of a broader mathematical literacy as defined by the OECD/PISA (2003: 24):

> Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen.

The following first example is concerned with teaching percentages in 7th grade. It shows how learners' common experiences can be linked to mathematical problem-solving and in what way exercises frequently encountered in the foreign language classroom can serve to "make sense of the mathematical solution in terms of the real situation" (OECD/PISA 2003: 27). The second example, which is intended for advanced learners (*Oberstufe*), focuses on the (mathematical) meaning of 'proof'. It is taken from a monolingual classroom setting (cf. Prediger & Kuntze 2005) but can easily be adapted to a CLIL setting. Again, procedures familiar from the foreign language classroom (essay-writing) can be employed in order to develop mathematical literacy.

Teaching percentages

A collection of materials on teaching percentages has been compiled by Katharina Prüfer and Daniela Geils in a class on CLIL material development under my supervision. Starting with the 7th graders' everyday knowledge of percentages (material 1) a more conceptual understanding of the mathematical phenomenon is developed. Material 2 offers a mathematical definition of percentages whereas the following materials provide related exercises.

In a similar fashion to the percentage squares in material 3, fractions and percentages are linked in another exercise (material 4), this time not necessarily taking exactly 100 squares as a point of reference. The pupils' conceptual understanding is consolidated with more exercises that cannot be documented here, e.g., a percentage domino or mixed questions like "A 10% service charge is added to the bill in a pizza place. If a meal costs £ 60, what will the final bill be?" or "The distance of a holiday trip is 320 miles. If the tourists have travelled 25% of their journey how many miles will be left?". These questions also allow for a discussion of typical cultural aspects (service charge, mileage). They also try to link the teaching of mere numeracy with the development of a broader mathematical literacy.

Resorting to a task format well-known in the foreign language classroom, a creative writing exercise (material 5) is set at the end to evaluate the pupil's language competence as well as their conceptual understanding. Coming full circle, this writing task again attempts to link mathematical concepts to everyday contexts and in this capacity corresponds to Prediger and Kuntze's (2005) perspective on the function of mathematical writing explained in Viebrock in this issue of *ForumSprache*. It has to be noted that the collection of materials itself does not necessarily imply prescriptions for its classroom use. Yet it could easily be employed in a collaborative and discursive approach to problem-solving.

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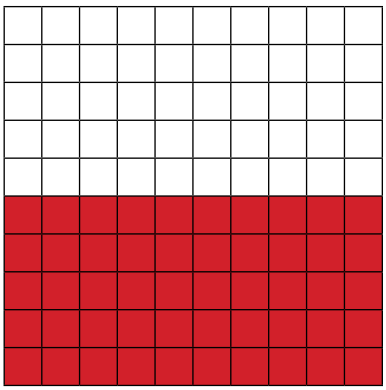
Vocabulary:

percent – Prozent
discount – Rabatt
sales – Ausverkauf
percentage – Prozentsatz
weather forecast
– Wettervorhersage

Questions for discussion:
Where do you know the presented symbols from?
Where can you find percentages in everyday life? What are they used for?

Examples:
Shops use percentages in sales.
Weather forecasts use them to tell us the chances of rain.

Material 1: Percentages in everyday life



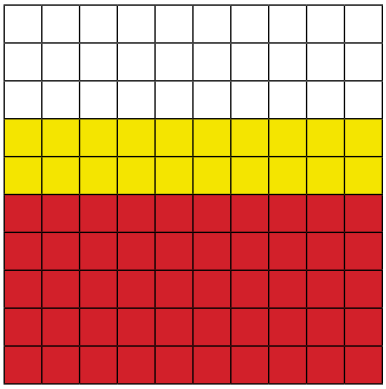
Look at this square.
It has been divided into 100 equal parts.

50 parts are shaded red.

We say fifty per cent is shaded red.
We write 50% is shaded red.
This is the percentage symbol: %

Vocabulary
square – Quadrat
to divide – teilen
equal parts – gleiche Teile
to shade – einfärben

30
20
50



Now 20 parts have been coloured yellow. 20 out of 100 is 20%, so 20% of the square is yellow.

There are 30 parts not shaded. 30 out of 100 is 30%, so 30% of the square is white.

What happens if you add up the percentages for the red, yellow and white parts?
50% + 20% + 30% = 100%
So the whole square is equal to 100%.

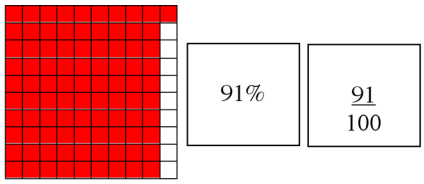
Vocabulary
to add up - addieren

'percent' means 'out of every 100'

Material 2: What does percent mean?

Materials adapted from: http://www.bbc.co.uk/skillswise/numbers/fractiondecimalpercentage/percentages/introduction/factsheet.shtml © Viebrock

Task: Fill in the gaps for each square. Which percentage is represented by the square? Which fraction?



Useful phrases:
… parts are shaded.
… out of 100 is … percent.
… percent of the parts are white/red.
… percent is/are represented by the fraction

Vocabulary:

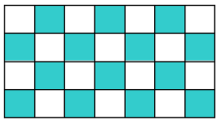
fraction – Bruch
to represent – zeigen, darstellen, abbilden

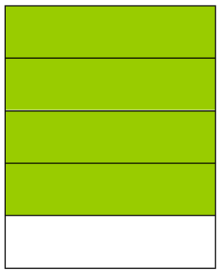
Material 3: Percentage Squares and Fractions (© Viebrock)

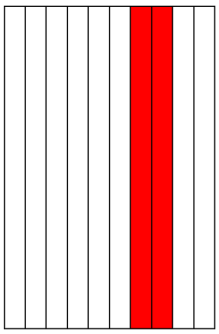
Task: Fill in the gaps for each figure. Which fraction is represented by the figure? Which percentage?

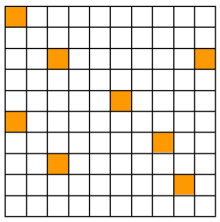
$\frac{5}{10}$

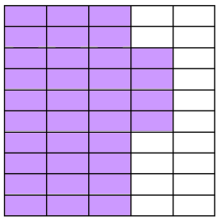
50 %

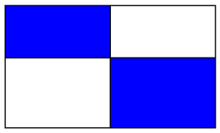


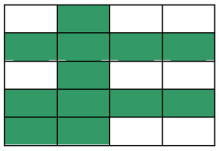












Useful phrases:
… parts are shaded.

$\frac{5}{10}$ of the parts are shaded/yellow.

That means ½ of the parts are shaded.

½ is equivalent to 50 %.
50 % percent of the parts are shaded.

Vocabulary:

to be equivalent to – gleich sein

Material 4: Fractions and Percentages (© Viebrock)

Sweaters are on sale. There is a discount of 10% on each sweater. Imagine you are the salesperson and a customer wants to buy two sweaters with a 20% discount.
What would you tell the customer?
Group in pairs and write a dialogue between the salesperson and the customer.

Vocabulary:
to imagine – sich vorstellen
salesperson – Verkäufer/in
customer – Kunde

Dialogue
Salesperson: Hello, how can I help you?
Customer: I need a new sweater and saw that they are on sale.
Salesperson: Yes, we offer a discount of 10% on each sweater.
Customer: Oh, that's not bad. Does that mean I get a discount of 20% if I buy two?
Salesperson: I am sorry …
Customer: …
Salesperson: …

Material 5: At the sales (© Viebrock)

Developing mathematical literacy through a cross-disciplinary approach

Especially the task presented in material 5 is an attempt to go beyond the boundaries of teaching numeracy to tasks that allow for the development of a broader mathematical literacy as explained above. Another example that has been suggested by Prediger and Kuntze (2005) for a monolingual German classroom could easily be adapted for a CLIL approach: A good starting point for a multi-contextual approach would be Simon Singh's book *Fermat's Last Theorem*, the TV documentary on the topic, or the materials and excerpts presented on the author's homepage (cf. http://www.simonsingh.net/) for that matter. In his book, which is written like a detective story, Singh traces the 300 year long attempt to prove Fermat's last theorem, a seemingly simple proposition: the equation $x^n + y^n = z^n$ has no solution for any integer greater than 2. The mystery around Fermat's last theorem, which was finally proved in 1995 by Andrew Wiles, has triggered not only mathematical efforts, but also many artistic expressions (poems, short stories, even a musical) that could be utilized in a CLIL approach. The focus of this example is not so much on the mathematical content since the actual proof of the theorem is highly complex and only comprehensible to a very limited number of experts. It is much more about the nature of mathematics as a discipline, its continuous flux and the process of constructing new mathematical knowledge. It would very well illustrate the culturalistic view of the discipline explained in Viebrock in this issue of *ForumSprache*.

The way Singh's book can contribute to a better understanding of a mathematical concept, as opposed to the use of a term in other domains, can be demonstrated with an excerpt from a pupil's mathematical essay provided by Prediger & Kuntze (2005):

> Themenstudie: Quod erat demonstrandum
>
> Man kann sagen, dass ein Beweis ein Nachweis der Richtigkeit eines Satzes oder einer Behauptung ist. Jedoch lässt sich keine allgemeingültige Definition des Begriffs „Beweis" aufstellen, dass es zunächst verschiedene Bereich und Kriterien gibt, nach denen differenziert werden muss.
>
> In Simon Singhs "Fermats letzter Satz" wird deutlich der Unterschied zwischen dem naturwissenschaftlichen Beweis und dem mathematischen Beweis betont.

> Ein klassischer mathematischer Beweis besteht aus logisch nachvollziehbaren Schritten, die auf Axiomen und Definitionen basieren, und somit zu einer unbestreitbaren Schlussfolgerung führen. Wissenschaftliche Theorien können nie solch absolute Geltung beanspruchen. Auch wenn diese Theorien aufgrund von Beobachtungen und Experimenten als „bewiesen" gelten, lässt sich hier um den Begriff „Beweis" streiten, denn Wahrnehmung ist fehlbar und auch noch so viele Experimente könnten rein theoretisch auf Zufall beruhen. Folglich sind die Ergebnisse wissenschaftlicher Beweise eigentlich nur höchstwahrscheinlich wahrer Behauptung (sic) [...]. (Prediger & Kuntze 2005: 2)

The learner Anna examines the meaning of "proof" and compares its use in different contexts. At the end of her essay, she develops what Prediger & Kuntze (2005: 4) call an "interdisziplinär angelegtes Ordnungsystem" (an interdisciplinary system of ordering concepts). It can be assumed that Anna has developed a thorough understanding of the concept in maths as well as in other disciplines. The originality of her writing as it is shown in the irony of her last sentence certainly demonstrates quite a conceptual mastery:

> Letztlich gibt es Beweise, die für Einzelne von Bedeutung sind (in einem Zivilprozess beispielsweise) und Beweise, die für alle von Bedeutung sind. Darunter gibt es wiederum Beweise, die sehr lange gültig sind, aber vielleicht irgendwann von anderen Beweisführungen umgeworfen werden (Daltons Theorie über die Atome als Bausteine des Universums, die mit Thomsons Elektronentheorie widerlegt wurde), aber auch Beweise, die Jahrhunderte lang überzeugen (Pythagoras) und auf die man auch heute noch aufbaut.
>
> Ob es bei all diesen Beweisen um Wahrscheinlichkeit, Wahrheit oder Glaubhaftmachung geht, ist von Fall zu Fall verschieden. Eine vollständige und allgemeingültige Definition des Begriffs „Beweis" kennt wohl nur Gott, aber dessen Existenz ist ja auch nicht eindeutig bewiesen. (Prediger & Kuntze 2005: 4)

Conclusion

Both examples show that materials and methods that are usually associated with the foreign language classroom, i.e., reading and responding to (excerpts of) novels, writing dialogues etc., can be successfully employed in a CLIL approach to mathematics in order to develop a broader mathematical literacy. At the same time, it becomes clear that in a way all teaching is teaching language(s), and that subject-matter competence is acquired communicatively and discursively (cf. Leisen 2005, 2007). This does not mean that content-oriented classes should give way to more explicit foreign language teaching, but it acknowledges that language is a necessary condition of learning content matter. Language also evolves from the contents of a class and becomes more and more refined in the process of developing a topic.

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