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ASSESSMENT INSTRUMENTS FOR CLASSES INTEGRATING MATHEMATICS AND FOREIGN LANGUAGE TEACHING

Abstract: The paper strives to examine some of the aspects of testing integration both within and across the domains of mathematics, and language proficiency. It tries to contribute to the effort of developing alternative assessment approaches that should reflect the interaction of both internal and external factors in the cognitive and linguistic development of bilingual students.

1. Focus of the paper

Several new trends related to methodology and foreign languages can be observed in the Czech schools of today. One of them is **Content and Language Integrating Learning** (**CLIL**). "European CLIL is highly diverse with many different types commonplace." (Marsh et al., 2001). Overseas, similar programmes have a long tradition. Most of them deal with the students for whom English is a second language, e.g. (Barwell, 2001), (Khisty, 2001). Unfortunately, such programmes are often viewed as compensatory (Irujo, 1998). Czech CLIL on the other hand is aimed at a relatively small group of carefully selected students with high ambitions. Their learning characteristics probably differ in terms of cognitive, psychological and social factors. The students enrolled in the programme are highly motivated, intelligent, and they have positive attitudes towards the target language culture.

In European CLIL it is believed that content, e.g. mathematics, and a foreign language, e.g. English, can be better developed through gradual interplay (25 – 100 % of the content is taught in a foreign language). Czech CLIL administered through the Ministry of Education is an experiment involving less than 20 schools with students aged 14-19 who learn the maximum of six of their curriculum subjects in a foreign language. The first year of the 6-year programme stresses the language preparation. As a result, 100 % of the second year mathematical content can be taught through the medium of a foreign language (English, German, Spanish, French, or Italian).

The relationship between foreign language teaching and mathematics has been the topic of several papers, see e.g. (Czarnocha & Prabhu, 2000). Many studies have been written about bilingual learning, teaching and assessment, especially in the USA and Canada (cf. Gonzales, 1999). The aim of the present paper is to identify suitable assessment instruments for bilingual education in the Czech Republic. We believe that the existing assessment instruments correspond neither with the principles of bilingualism nor with the local conditions and should therefore be modified. Our research deals with mathematics taught through the medium of the English language. Essential questions are: Does assessment reflect the link between the language and mathematics? What are the most suitable assessment instruments for this type of education?

2. Theoretical framework of the study

The issue of assessment in bilingual programmes needs to be contextualized in several levels of theoretical framework - the comprehension of the student learning of mathematics and the study of second language acquisition, and seen from a broader psychological, sociological and cultural perspective. The assessment of bilingual students itself comprises both theoretical and practical approach, with works ranging from classroom-based research studies to theoretical models of assessment principles.

In European CLIL, one of the major concerns is the dual-focused assessment, i.e. how to assess (accurately in an integrated way) the ability of the students' development e.g. in both mathematical thinking and English.[1]

Bilingual students´ performance is measured and assessed e.g. by dominance tests, proficiency tests, diagnostic tests, placement tests, and achievement tests. Most of them seem to be more concerned with the language. The students' progress, however, must also be measured through ongoing assessment of achievement in the content area – mathematics. Thus the integrative approach seems to be an ideal intersection of mathematics and foreign language assessment. Due to traditional and rather conservative approach to assessment in the Czech Republic, we believe that achievement tests could be seen as most suited to measure both the areas of development. Moreover, they can also be used for diagnostic purposes.

[1] In foreign language teaching, assessment is used in the sense of proficiency of the language user. Procedures cover many different test types, cf. Modern Languages: Teaching, Learning, Assessment. A Common European Framework of reference. Council of Europe, Strasbourg, 1998.

In our opinion, the aim of assessment is to assist the learning process as a whole rather than collect records of the students' success and failure. Unlike the traditional view of assessment, which highlighted the learning product, the contemporary approach emphasizes learning and consequently its assessment as a dynamic process. This shift of perspective is well documented by Duval who argues that: "The characteristic feature of a cognitive approach is not to look at student difficulties … but to determine the cognitive functioning underlying the diversity of mathematical processes." (Duval, 2002, p. 1) Similar ideas are in the American NCTM Standards which formulate aspects of assessment having increased or decreased emphasis, see e.g. (Verhage & De Lange, 1997).

In (Van den Heuvel-Panhuizen, 2002), the need of making the assessment more related to goals and teaching methods results from the recent change of goals in mathematics. Facing this significant change and the related new educational strategies, the alternatives for standardized testing are to be developed and implemented. Several criteria for test construction are discussed in (Van den Heuvel-Panhuizen, 2002). Seeing them through the perspective of teaching mathematics in a foreign language, the insufficiency of traditional forms of assessment is obvious. For example, the request for unidimensionality, i.e. "the assumption that an examinee's response to a test item can be attributed to a single trait or ability" (Van den Heuvel-Panhuizen, 2002), is not fulfilled. The danger of ambiguity is rooted in the interaction of the mother tongue, the foreign language and the language of mathematics. To overcome this difficulty we propose to use two types of assessment: a complex, structured test covering a number of items (see 4.1) for the teacher assessment of the learners' performance and portfolios (see 4.2) as a means of long-term student self-assessment.

3. Preliminary findings

In order to carry out research we addressed two Czech upper secondary schools where mathematics is taught in English as a foreign language. We visited the schools on a number of occasions, first getting acquainted with the methods of teaching, then testing. We talked to the teachers and students, video-recorded parts of the lessons, examined some of the entrance and final tests, the approaches to testing and the prevailing assessment procedures, e.g. the proportion between teacher and student assessment.

Here are some of the most striking findings: Final, i.e. school leaving, exam differs significantly in its format. Whereas in one school the exam takes the form of an oral test (15 minutes preceded by 15 minutes to prepare in writing), the other school administers both oral (15 plus 15 minute) task and a written, 4 hour, test. The assessment of candidates' achievement consists of 40 % (the oral part) and 60 % (the written part) of the test. In Mathematics in English tests neither of the schools assesses the examinees' language proficiency. Language errors are not taken into consideration.

That was the main reason why we decided to develop and administer a relatively simple but carefully structured mathematical problem which would clearly illustrate the dependence of the learner‘s ability to solve the problem mathematically on his/her ability to understand the task linguistically. The secondary aim of the test was to show the teachers the necessity to also assess the language aspect of the task.

4. Methodology

Our suggestions for assessment procedures relate to teacher-made tests, and not to standardized tests produced by professional test-makers. The main reason for this decision is that the test itself is an imperfect tool showing the product, i.e. the immediate results of the learning process.

4.1. Complex test

After deep study of resource materials we made a decision to create a complex structured test covering a number of mathematical as well as linguistic items. Some of them were graded with regards to difficulty.

Example[2]:

Put the following into the mathematic notation:

1. *There are more people in York than in Exeter.*
2. *There are not so many people in Exeter than in Bristol.*
3. *There are roughly four times as many people in Bristol as in York.*
4. *The population of York exceeds that of Exeter by about 30,000.*

[2] The problem is an authentic material.

5. *The total population of York and Exeter is less than half that of Bristol.*
6. *There are at least 350,000 more people in Bristol than in Exeter.*
7. *The population of Bristol exceeds that of York by more than that of York exceeds that of Exeter.*
8. *If York were five times as populous as it is, it would have more inhabitants than Bristol.*
9. *The total number of people in the three cities is 623,000.*
10. *The populations of Exeter and Bristol differ by about 363,000.*

In the following text we present the mathematical and linguistic analysis of the text.

a) Mathematics: The nature of all items is one of *comparing*, No. 1 and 2 being the easiest tasks, No. 5 and 7 the most difficult ones. Formulas representing the relations cover e.g. $<$, $=$, $+$, $\cong$.

b) English language: With regard to *comparing* the linguistic analysis states the following: comparative forms and adverbs (less, more, etc. in No. 1, 5, 6, 7, 8), some specific verbs (exceed, differ, etc. in No. 4, 7, 10), correlative conjunctions (as…as in No. 3, 8), prepositions ((exceed) by, (differ) by, etc. in No. 4, 7, 10).

Some of the tasks give evidence of greater difficulty in mathematics, some in English, and some in both domains, see the wording of the problem and the following table.

Examples (↑- increasing difficulty, ↓ - decreasing difficulty, = - unchanged level of difficulty)

M =	L ↑	Task 1 → Task 2
M ↓	L ↓	Task 7 → Task 10
M ↑	L ↓	Task 5 → Task 9
M =	L ↑	Task 4 → Task 6
M ↑	L ↑	Task 1 → Task 7

4.2. Portfolios

Whereas the preceding testing instrument (4.1) concerns teacher assessment of the learners' performance, the following text introduces portfolios as an example of long-term student self-assessment. Foreign language teaching has recently seen the implementation of portfolios as a suitable alternative instrument of assessment. Their main advantage is that they assess students' progress over time. Moreover, students themselves share responsibilities for their learning.

A portfolio consists of three components:

- The Passport: provides and overview of the individual's proficiency at a given time; the overview is defined in terms of skills and the common reference levels
- The Biography: facilitates the learner's involvement in planning, reflecting upon and assessing his or her learning process and progress
- The Dossier: offers the learner the opportunity to select materials to document and illustrate achievements or experiences recorded in the Biography or Passport.

In teaching, portfolios have two functions:

- Reporting: Displays the owner's capabilities in relation to mathematics and foreign language
- Pedagogical: a means to making the mathematics and language learning processes more transparent to learners, helping them to develop their capacity for reflection and self-assessment

The implementation of portfolio in Czech bilingual education is a long-term process. At the moment we are in the initial stage of CLIL portfolio development.

5. Research results

The research results concern the complex test described above (4.1). After collecting data, the analysis of results was carried out in order to clarify the relationship between the students' cognitive development in mathematics and their language proficiency. Several areas of difficulties were identified. It was obvious that each student needed some prior knowledge of vocabulary and grammar to understand the instructions. Partial language misunderstandings prevented the students from successful completion of the task.

The choice of tasks requiring application of several ideas facilitated holistic approach to assessment. At the same time it helped determine error location – in the knowledge of mathematics or/and English language.

Examples:

No. 4 correct, No 7 incorrect:	Error origin – mathematics
No. 1 correct, No. 2 incorrect:	Error origin – English language

The greatest mathematical difficulty for the students was the distinction between smaller and bigger. The greatest language difficulty was identified in misunderstanding approximating adverbs (roughly, about in No. 3, 4, 10).

Disclosing the patterns in errors provided evidence of the interrelatedness between mathematics and English language knowledge. To assess mathematics and English independently is wrong, all domains included in the assessment instrument need to be assessed in an integrated way.

It follows that the close cooperation of mathematics and foreign language teachers is indispensable for a variety of reasons: preparing tests, correcting, assessing and remedial work. The three co-authors are teacher educators with a long teaching experience: a didactician of mathematics, an expert in teaching English as a foreign language methodology, and a linguist.

6. Concluding remarks

Generally speaking, all the assessment approaches should reflect the interaction of both internal and external factors in the cognitive and linguistic development of bilingual learners. All the assessment instruments should consider internal factors such as aptitude, intelligence, and age of learners, as well as external factors, i.e. sociological and cultural background.

The paper examines some of the aspects of testing integration and contributes to the effort of developing alternative assessment approaches. The integration of content and language is an educational challenge all over the world, assessment being just one of the burning issues. Further discussion might bring more light to entrance assessment of immigrant children and their integration into the mainstream education.

We conclude with the citation from (Verhage & De Lange, 1997): "Although assessment is not an educational goal in itself, it appears to be so important that it can be used as an instrument to realize changes in mathematics education in general. It is the task of the community of mathematics educators to take care that these changes go in the desired direction."

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