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INTELLECTUAL-SPEECH TASKS IN THE COURSE OF BILINGUAL TEACHING MATHEMATICS IN HIGHER EDUCATION

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Abstract

The language environment in the Republic of Tatarstan (Russian Federation) is multilingual. According to the Ministry of Education of the Republic of Tatarstan, there are about 1256 schools with the Tatar language of teaching, and 410 schools, where teaching is conducted on a bilingual basis (Tatar-Russian, Chuvash-Russian, Mari-Russian, etc.). The aim of this work is to study the role of intellectual-speech tasks against the background of bilingual (Tatar-Russian) teaching in professional training of a civil engineer. The causes of segregation between thinking and speech in the second language can be clarified relying on the principle of unity of language and thinking, as well as the ways for their unification by means creating a scheme of educational intellectual-speech tasks. Teaching mathematics against the background of bilingualism, using methods of solving intellectual-speech tasks makes it possible to: analyze and compare mathematical content in different languages; improve the culture of mathematical speech in Russian and Tatar languages; improve speech and cognitive mechanisms.

Keywords: Bilingual education, language, mathematics, speech, thinking.

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1. Introduction

In 1990, the share of Tatars, who were studying in their native language, was about 24%; by 2012, this figure reached 47% (data provided by the Ministry of Education of the Republic of Tatarstan). At some universities of the Republic of Tatarstan, teaching is conducted on a bilingual basis (Russian-Tatar, Tatar-Russian). As a rule, bilingual education is provided at junior courses, which allows students to adapt to further education in Russian.

The heart of professional education are general education disciplines, the most important of which is mathematics. From the linguistic point of view, the language of mathematics is among the simplest, since the language of mathematics is not so rich and diverse; its syntactical structure is very formalized, while grammatical structure is rather simplified. The major role in the process of teaching mathematics belongs to special mathematical texts, created based on the language of teaching mathematics.

The problem of relations between thinking and speaking is very complex. Vygotsky (1999, p.380) described this as a process '...starting from the motive that generates a thought, to the formulation of the thought itself, to mediating it in the inner word, then in the meanings of the outer words and finally in the words'. One of the most effective methods that facilitate the unification of thinking and speech in the process of bilingual teaching of mathematics is the method of solving intellectual-speech tasks.

2. Problem Statement

The theoretical basis of our research are the works of Russian scientists Gnedenko (2000), Khinchin (2000), who investigated development of speech in the process of teaching mathematics in close connection with formation of thinking culture. We also relied on the works of foreign scientists Ellerton and Clarkson (1996), Barwell (2014), dedicated to studying the role of language in teaching mathematics. The studies by Barwell, Moschkovich, and Staats (2008) clarify the notion of 'academic language' with regard to the sphere of mathematics.

According to the 'Theory of thresholds', formulated by Cummins (1991, 2000), bilingualism can positively influence the intellectual development of an individual only if the individual has developed bilingual competence. The results obtained by Cummins (1991, 2000), suggesting that bilingual students master math better if they are fluent in both languages, are confirmed in the works of Clarkson (1992), Clarkson & Dawe (1997), Moschkovich (2002), Planas and Setati-Phakeng (2014), which are of both theoretical and practical interest.

The study by Salekhova and Tuktamishov (2011) proposes a technique that uses intellectual-speech tasks. In this context, intellectual-speech activity is understood as a single process of generating thought and speech, which constitutes the material basis of communication. The problem of the research are to clarify the causes of thought and speech disunity in the second language as well as to apply a set of educational intellectual-speech tasks in bilingual education.

3. Research Questions

The problem in general consists in revealing and using the pedagogical potential of educational bilingualism in professional training of students at the universities of the Republic of Tatarstan. Teaching mathematics in the second language assumes that a student has to concentrate not only on the content, but also on the form of presentation. Usually, when studying in a second language, students translate or interpret an unknown concept into their own language, but in such case, there is no real process of generalizing the phenomena of objective reality. Thinking activity is based on reflective capacity of a person and performs a cognitive function, while solving intellectual-speech tasks appears as a variety of the first, but with a ‘function’ of secondary cognition (Glukhov, 2014).

4. Purpose of the Study

The aim of the research is to study the role of intellectual-speech tasks against the background of bilingual (Tatar-Russian) education in training of a civil engineer. In the course of solving intellectual-speech tasks, the cognitive activity is focused at a non-linguistic subject; speech is practiced in mental activities; this leads to automatism of verbal activity; the teacher can control mental and verbal actions.

5. Research Methods

This study is based on the fundamental assertion about the unity of language and thinking in the course of teaching mathematics against the background of bilingualism. This suggests that the mathematical language becomes not only a means of learning, but also the learning goal.

Here it is necessary to use techniques relying on students' knowledge obtained in monolingual mode, because formation of mathematical conceptual apparatus in a second language comes as a recognition of already known concepts and relationships. At the same, since there is no isomorphism between languages, it is particularly important, when introducing new concepts, to provide a ready concept or definition, which would take into account the semantic field of a word in the focus of the speech utterance. At the same time, it is very important to avoid both lexical redundancy and lexical insufficiency.

Teaching mathematics on a bilingual basis deploys various types of intellectual-speech tasks: conceptual-lexical, purely mathematical and situational-mental ones (Salekhova, 2008). A concept-lexical problem presents a new mathematical concept in the second language. An essential property of the concepts - lexical task method lies in the fact that understanding by students is achieved without translation. Purely mathematical problems to allow for programming a certain amount of mental operations to a specific vocabulary and, in the framework of the question-answering system of problem solving, to track each student's pace. It distracts students’ thinking activity from a foreign language form, directing it to the real object of cognition.

To illustrate the application of intellectual-speech tasks using conceptual-lexical and purely mathematical problems, we, hereby, provide a fragment of a lesson dedicated to ordinary differential equations. The lesson is nominally divided into two parts. The first part is dedicated to solving, with teacher’s help, conceptual-lexical problems in the second language, which implies mastering of new concepts. Thus, as a result of this topic presentation, the students achieved an uninterrupted understanding of the following concepts and terms: an ordinary differential equation, a general solution of a differential equation, an equation with separated (separable) variables, a general integral etc.

The second part refers to solving mathematical problems using the new vocabulary of the first part. The teacher announces the topic at the blackboard and explains the material.
Equations with separated variables (The teacher writes the topic of the lesson on the blackboard).

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These equations have the following form

dy/dx = -M(x)/N(y) or an equivalent form

M(x)dx+N(y)dy=0, (3)

where M, N are accordingly functions only of x and only of y. The solution of this equation is obtained by direct integration

∫M (x) dx + ∫N (y) dy = C,

where C is an arbitrary constant. Let's consider a differential equation with separable variables.

Equations with separable variables. Such equations have the following form

y'= -M(x)N(y)/M'(x)N'(y) (4)

or an equivalent form

M(x)N(y)dx + M'(x)N'(y)dy = 0, (5)

where $M(x), N(y),\ M'(x), N'(x)$ are known functions. Solving such an equation requires performing the following steps.

The first step. Getting rid of fractions, if any (form (4)).

The second step. Connecting all the terms containing one and the same differential into one. The equation takes the following form (5).

The third step. Further reducing the differential equation to the form (3). After which the equation takes the following form

M(x)/M'(x) dx + N'(y)/N(y) dy = 0,

The fourth step. Integrating each part separately, as in (3).

Example. Then the teacher solves the example together with the students. The teacher writes down the following equation on the blackboard.

dy/dx = $(1 + y^2)/((1 + x^2)xy)$.

Teacher: Is this equation a differential one?

Student1: Yes, because it contains a derivative. This is an ordinary differential equation of the first order.

The first step. The teacher asks student 1 to perform the first step

$(1 + x^2)$ xydy = $(1 + y^2)$ dx

The second step. *Teacher: Is the equation an equation with separated variables?*

Student 1: is it, as it seems to me.

Student 2: No, it is not, because there are expressions, written before the differentials, which depend on both x and y.

Teacher: Student 2 is right and this is the key point. The variables are not yet separated; student 2, try to separate the variables in the equation

$(1 + y^2)$ dx - x $(1 + x^2)$ ydy = 0.

Student 2 (after some consideration): To separate the variables, we need to go to the third step, and with this aim we should divide both sides of the equation by x $(1 + x^2)$ $(1 + y^2)$. These results in

dx/((x(1 + x^2)) –ydy/(1 + y^2) = 0.

The teacher: Good. Next, let us move on to the fourth step. We need to integrate the resulting expression. Here we need to recall the table of indefinite integrals and the methods of integration that we studied earlier. In this case, it is necessary to recall the methods of integration for a fractional-rational function.

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A brief work on reviewing the corresponding formulas is carried out, and then the integrals are calculated.
Teacher: the result can be written in a form $(1+x^2)(1+y^2)=Cx^2$*- is the general integral of equation.*
Next, the teacher gives examples for individual solution.

Here we need to identify in general terms the mental operations, which are performed by students at each step in the process of solving the problem.

The first step. Analysis and synthesis (transformation included in the first step involves analyzing an expression and bringing it to standard (that's where synthesis is applied) form.

The second step. Comparison, classification, i.e. distribution by group. Here the equation was assigned to a class of equations with separable variables.

The third step. Analysis and synthesis, specification, as possible connections within the object (links between members of an algebraic expression) are established.

The fourth step. Analysis and synthesis, comparison, abstraction, comparison specification.

This shows that the most important mental operations for solving the problem are those of the second and the fourth steps. Solving such problems allows to secure, first of all, such mental operations as analysis and synthesis, classification, comparison, abstracting. This enables the teacher to put points for solving a problem.

5 points. 1. The ability to represent the problem in the form of a differential relationship and to discern the form (class) of a differential equation.

$M(x)N(y)dx + M'(x)N'(y)dy = 0$.

2. Transformation of the equation, separation of variables, reduction of the equation to the standard form.
3. Representation of a solution in the form of an algebraic sum of integrals.
4. Transformation of integrands, reducing them to table integrals. a). When integrating an arbitrary constant, not to lose and not to get two arbitrary constants instead of one. b). Bring the general solution to the simplest form.

4 points. The student complies with points 1 to 4, but makes errors in paragraph 4 in subparagraphs (a) and (b).

3 points. The student determines the type of the equation, complies with points 1-3, but cannot find the primitives of integrals.

2 points. The student can perform steps 1-2.

1 point. The student can perform step 1.

0 points. The student cannot perform any of points.1-4.

An experiment was conducted at the Kazan State University of Architecture and Engineering (KSUAE). The participants were given four problems, similar to those given earlier, for individual solving. The participants were first-year students of the KSUAE Construction Institute, who entered the university in 2016. The number of participants was 31. Table 01 shows the results of the experiment.

Table 01. Results of the experiment

Point	5	4	3	2	1

Number of students	7	9	13	2	0

6. Findings

As shown by experiments, the greatest difficulties for students in performing such mental operations as abstraction, analysis and synthesis. The problems associated with vocabulary are mostly removed as a result of solving the conceptual and lexical problems of the first part of a problem. Only two individuals out of the thirty-one did not fully understand the formulation of the problem as well as, due to poor mastery of the previously explained concepts and terms, the meaning of the differential equation solution. The difficulties of the remaining students are not of conceptual-lexical nature and coincide with the difficulties that occur in students studying in their native language.

7. Conclusion

Thus, teaching mathematics, against the background of bilingualism, using methods of solving intellectual-speech tasks makes it possible to:

- analyze and compare mathematical content in different languages, therefore, cultures, which enhances the professional orientation of teaching;
-improve the culture of mathematical speech in Russian and Tatar languages;
- improve speech and cognitive mechanisms, logical memory; fill gaps in both the native and the second language;
- strengthen cognitive interest and motivation in intercultural communication.

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