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**TRANSFER: CONDITION OR RESULT OF MATHEMATICS
LEARNING IN SCHOOL?**

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Abstract

Rethinking the entire educational process, implicitly the mathematics education, in terms of skills training, requires identification of learning strategies to support this goal. The teacher's role requires the ability to instrument the student with such means to facilitate learning and contribute to a sustainable and effective learning. *Background.* Correlative to the notion of competence is the transfer learning, approached on the one hand, as a facilitating learning strategy, helping to build a coherent and logical mathematical knowledge, and on the other hand, as the purpose of learning. Mathematical competence, translated by the ability to mobilize knowledge to practical problem solving situations involves transfer of knowledge. *Purpose.* The present study aims to highlight the importance of the transfer in the learning of mathematics at secondary school, which is the forming stage in mathematics component of the general culture of any individual. *Methodology.* The research focused on two directions: a theoretical direction, making capital out of the most significant results of studies conducted on transfer in learning, and the empirical one, focused on investigating directly by questionnaire secondary school students' opinions on strategies for learning mathematics. *Results.* Although strategies for implementing the transfer of learning should be explained in the classroom, it leaves most times up to student always unprepared in this respect and therefore it is carried out sporadically and to a very small extent compared to its importance. *Conclusions.* Without this transfer, mathematical knowledge remains isolated, not integrated into the student's field of knowledge, deprived of flexibility, operability and functionality.

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Keywords: Learning strategy, mathematical competence, transfer



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1. Introduction

Regarding the transfer, this vector dimension to learning process, the specialty literature includes phrases like: "*the keystone of learning*, without which knowledge is threatened to split in tens of thousands of particular cases" (Raynal, & Rieunier, 2005), or "*the philosopher's stone* of teachers" (Mendelsohn, in Raynal & Rieunier, 2005). These approaches in learning transfer were confirmed by school practice.

In the present study, the issue of transfer is seen from the perspective of the didactics of mathematics in the context of research undertaken to identify and explain the causality of obstacles and errors in learning this aspect of knowledge. Thus, in the range of variables to be taken into account by specialists in didactics of mathematics in their efforts to find solutions to achieve an effective teaching process, transfer must also be included. The complexity of increasingly sharp expertise, the increasingly higher demands of society in general, and the dynamic of changes in the situations in which students, future adults, will need to perform based on their knowledge acquired during their training are just some of the factors that create a strong pressure on teachers and students on teaching or learning mathematics. One of the solutions recommended by research in the field, whose effectiveness is proven by practice, is the use of transfer strategies in learning. In this regard, Develay & Meirieu (1992) stated "As long as the students are not able to use the knowledge acquired in different situations, as long as they cannot pinpoint the problems that require a solution or other, the questions that demand a certain answer [...] they remain dependent on the acquisition situation thus meaning that we cannot define it as a learning situation. Therefore, it is very important to practice what American researchers call *bridging*, which implies that after assimilating a notion or procedure to ask the students to find on their own situations in which they can detect and apply it".

2. Problem Statement

From the multitude of perspectives from which the issue of transfer can be approached in learning mathematics, we will focus on the link between transfer and mathematics competence. According to Scallan (2004), "competence is the ability of an individual to mobilize in an internalized way an integrated multitude of resources in order to solve a problem-situation family". Mobilized resources must be targeted and contextually applied, depending on the particularities of the new situation and the carrier vector of these resources is transfer. Thus, in our view, transfer is a structural component of competence.

Hereinafter we will make a brief foray into the specialty literature of transfer.

2.1. Some definitions of transfer. Notions/concepts associated with the notion of transfer extracted from researches

To create a conceptual basis of reference for the present study, we selected some definitions, which we considered to be significant to this approach: 1) "applying a known solution to a new situation, unencountered before" (Raynal & Rieunier, 2005). In the view of the same authors, attaining transfer is an intelligent activity, that requires "transferring an achieved behavior in a problematic situation (x) to a problematic situation (y) of similar structure, but with different data perceptively speaking" (op. cit.); 2) "any influence, positive or negative, which the learning or practicing of a task can have upon subsequent

learning or performances”(Crahay & Dutrévis, 2010, p. 3), “use of previously acquired knowledge to a new situation” (Legendre, in Scallon, 2004).

The study of transfer strategies involves two categories of interrogations: *what is transferred?* and *how is transfer accomplished?* Regarding the first question, there are two categories of contents of transfer: *operative mental structures* (ways to tackle the situation and mental operations) and *cognitive mental structures* (knowledge), each having a fundamental role in supporting the learning experience. Regarding the manner of carrying out the transfer, the second question associated to it, research and practice offer two answers: on the one hand we can talk about *vertical transfer* (type of transfer which allows a better understanding of the existent links between different complexity level pieces of knowledge, more precisely between basic abilities and complex abilities) and *horizontally /transversally (inter- and intra-disciplinary) transfer* (that makes connections between knowledge of a field of knowledge and the interconnected areas or concrete practical situations for their application).

Research on the notion of transfer highlights a series of associated notions / concepts / syntagmas:

- Context of learning (physical or affective) (Richard & Ghiglione, 1992)
- Specific encoder (Tulving 1976, in. Raynal & Rieunier, 2005)
- Indices of information recovery from Long term memory (Raynal & Rieunier, 2005) .
- Contextualizing – decontextualizing – recontextualizing: characteristics of an efficient learning situation (Raynal & Rieunier, 2005).
- Ability to generalize and capacity to abstract (Raynal & Rieunier, 2005).
- Acquisition and retention (Crahay & Dutrévis, 2010).
- Structural isomorphism between two situations (one for which we have the solution, while the other one is new): when solving a problem, researches have showed that ”experts immediately search for profound structure indicators, contrary to novices (beginners) who cannot percept but surface indicators, strongly related to content” (Raynal & Rieunier, 2005). In opinia acelorasi autori, psychologists distinguish between structure features (logical operations necessary for solving an issue) and surface features (the form, the exterior aspect of the statement) specific for a problem. What draws the attention to a problem are mainly the surface features (with an essential role in transfer attainment), which based on an analogical way of thinking, can sometimes lead to important errors, while structural features are less accessible, and their detection implies the students’ effort and experience. This ability to identify and distinguish not only surface features, but also structural ones develops with time, during the lessons. In this manner, the students will be able to critically analyze the issues they encounter, on one hand to sense the transfer opportunities among problems with similar structures, and on the other to prevent error emergence as a result of transfer/ interferences between surface similarities, but with different structure.
- The development of automatisms: “...for being able to address new and complex issues, a certain number of basic procedures need to be automatized (in arithmetic, language, writing, etc.)” (Rey et al., in Crahay & Dutrévis, 2010).
- The ranking of knowledge (Crahay & Dutrévis, 2010)
- Negative transfer (interference) of knowledge and competencies which generates learning error (Crahay & Dutrévis, 2010)

And certainly not least:

- The American theoretician of the instructional design, Gagné (1985), considered *transfer* as *the last learning event*, he was among the first who explained the importance of transfer in learning. In his opinion, one of the conditions that favours transfer is the similarity between the learning context (*source situation*, acc. Tardif, in Scallon, 2004) and the one in which performance is desired (*target situation*, Tardif, in Scallon, 2004).
- Astolfi has an interesting prospect of addressing transfer based on psychological theories on learning, shown in the table below:

Table 01. A comparative perspective upon transfer in school (Astolfi, 2004)

GENETIC PSYCHOLOGY Model (Development stages)	COGNITIVE PSYCHOLOGY Model (Information processing)
Priority is given to invariants' construction, by means of a progressive generalization and abstraction starting from the subject's experiences	Priority is given to the analysis of specific tasks, each involving and combining knowledge, procedures, algorithms and routines.
Central placement of common thinking schemes and rules for the diversity of situations	Central placement of diverse manners of problem solving, some similar
Structuralist point of view	Functionalist point of view
Cognition studied based on a general model of intelligence, according to the equilibrium mechanism	Cognition studied based on local models in which memory and its processes are mainly involved
<i>A priori</i> postulated transfer	Scepticism regarding transfer

2.2. The mathematical didactic perspectives of transfer

Research on the role of transfer in learning mathematics led to the conclusion that transfer can be learnt and it has to be done, by explaining the transfer mechanisms during learning. In this context, school should encourage transfer, without it being spontaneous, but permanently "postulated and organized, treated as a "transversal intention of schools' mission". The strategies for promoting transfer reside in a *positive attitude* towards it and, especially considering it as "a permanent activity and not as a simple transport of the acquired competency. Any authentic intellectual activity consists of bringing together two contexts, with the purpose of highlighting the similarities and differences between them. There is no separation between the knowledge stored in the memory and the ability to transfer..." (Astolfi, 2004).

In the same context, Meirieu (1987) considers that transfer supposes a metacognitive control realized by a student upon a cognitive activity and represents "an essential regulatory principle of the pedagogical activity, and that its mediation by means of teaching is decisive. The subjects do not progress unless they could change the framework, the personal experimentation of the work instruments which they possess in a newly encountered situation." This aspect regards *the decontextualizing* and especially *the recontextualizing* of knowledge and it is very important for the study of Mathematics, due to the fact that by its nature, Mathematics represents a work apparatus compulsory for other sciences.

The continuous nature of school learning processuality causes a double perspective on transfer: a particular sequence of its development should be considered both a result of prior learning and a subsequent learning condition. Thus, the transfer is both the condition of the learning process and a

desirable result of this process. In other words, transfer is the *alpha* and *omega* of learning process of mathematics.

3. Research Questions

The present study is part of a broader research aiming at analyzing obstacles and errors in learning Mathematics in the secondary level. This study was prompted by the need to identify and explain the factors that generate the very large discrepancy between the results recorded by participants in national and international math competitions (performance education) and the results recorded in the national evaluations (mass education).

In this context, the question underlying the present research aims to *what extent the mathematics curriculum for the secondary level has consistency in relation to the one for primary level, respectively with the high school one, in the sense of forming the adequate mathematical concepts and applicative representations for the gradient levels of complexity, and of assuring conexions between knowledge and the intra- and interdisciplinar transfer attainment.*

4. Purpose of the Study

The research was aimed at the study of the pedagogical approach of mathematical concepts from the perspective of transversal (intra- and interdisciplinary) correlations and of their spiral evolution.

5. Research Methods

We used questionnaire based survey to identify the level at which vertical transfer is applied and horizontal transfer is used in learning mathematics at secondary school level.

The questionnaire has been pretested on a lot of 27 students in the 8th grade and applied in 22 classrooms, representing 19 localities (12 from rural areas and 7 from urban areas) and it has encompassed 4 counties from the South-Eastern part of Romania (adding up to 350 students). The sample, randomly established, included 8th grade students.

6. Findings

6.1. Variable: *continuity and discontinuity of the mathematics curriculum in the secondary level*

Learning based on the mathematical concepts formation, as basis for the operationalizing of knowledge and transfer attainment, implies a continuous process of their elaboration on different levels of conceptualization, according to the specific characteristics of each stage of the individual's psychogenetic development. From this point of view, another possible source of obstacles is the discontinuities ("breaks") which occur at those levels' transition.

Item 1: *When I learn I make connections between the new mathematical pieces of knowledge and the ones previously acquired.*

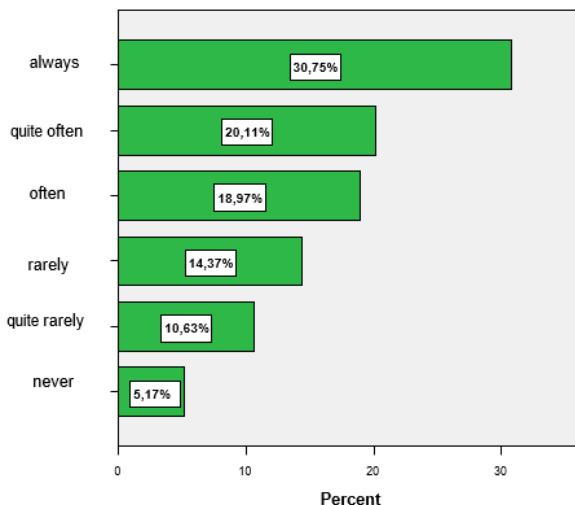


Figure 01. The distribution of responses on the connections between new and previous knowledge

The results reveal that over 30% of the students rather do not make connections between the mathematical pieces of knowledge, which means that when these pieces of knowledge are acquired, it is more a fragmentary, thus non-functional process.

Table 02. Correlation between "the students' results" and «the attainment of connections between pieces of knowledge»

Correlation Coefficient Spearman's rho	
N= 350	When I learn I make connections between the new mathematical pieces of knowledge and the ones previously acquired
The Mathematics average grade from the 5 th grade until the 8 th grade	,348(**)

** Correlation is significant at the 0.01 level (2-tailed).

As expected, there is an important positive relation ($\rho = .348$ at a significance level of .01) between the attainment of these connections between the students' Mathematics knowledge and results.

Item 2: *When teaching new pieces of knowledge in Mathematics, the teacher has shown us the relation between these and the ones previously acquired.*

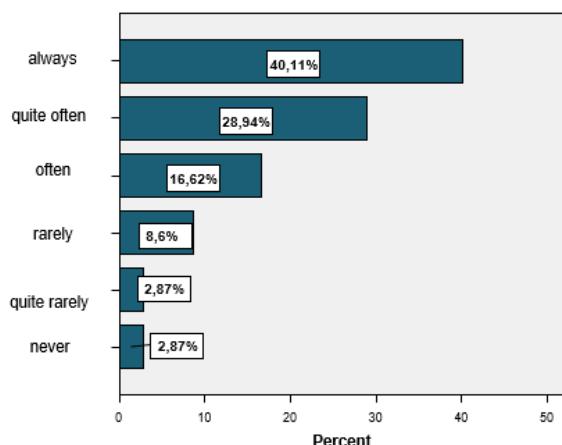


Figure 02. The distribution of responses on students' perceptions on vertical transfer conducted by the teacher

Out of the answers given by the students encompassed in the study it appears that in general (over 80% of the cases), when teaching new pieces of knowledge Math teachers highlight the elements of continuity between what the students have previously acquired and what they are in the process of acquiring. However, more than 10% claim that this happens rarely or quite rarely. Therefore, it is clear that Math teachers have included in their teaching strategies this dimension, important for the attainment of Mathematics learning.

Item3: The mathematical pieces of knowledge taught in the secondary level have been related to the ones from the primary one.

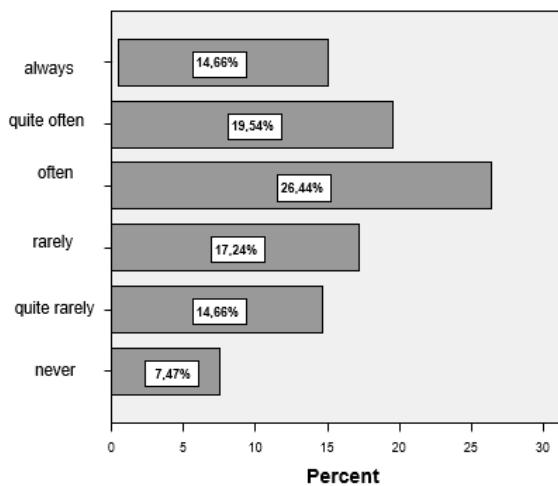


Figure 03. The distribution of responses on students' perceptions on continuity between school cycles

As far as the continuity between the mathematical pieces of knowledge taught in the primary level and the secondary one is concerned, to quite a great extent (almost 40% of the subjects) it has been ranked as rather unaccomplished.

Therefore, the small percentage of the cases (under 15%) in which the continuity elements between the Mathematics taught in the primary level and the one in the secondary level have been explained justifies the great part of obstacles with which students are confronted during the first part of the secondary level.

6.2. Variable: mathematics learning strategies in middle school

Item 4: When I learn, I make connections between the mathematical knowledge and the one acquired at the other subject matters.

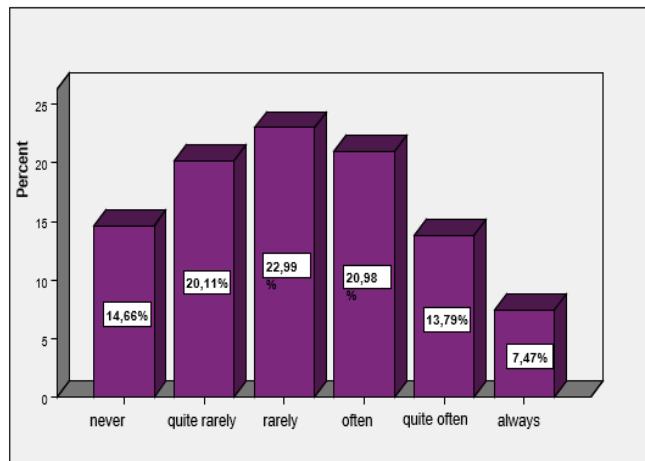


Figure 04. The distribution of responses on interdisciplinary transfer

The percentual value corresponding to those who always make this type of connection (7,47%) represents half of the value of the ones that do not ever make it. Moreover, it can be observed that more than half of the students participating in the survey rather do not make connections between the knowledge acquired during the Mathematics lessons and the one acquired at other subject matters.

Item 5: When I learn, I make connections between the mathematical knowledge and the possibilities of transferring it in everyday life.

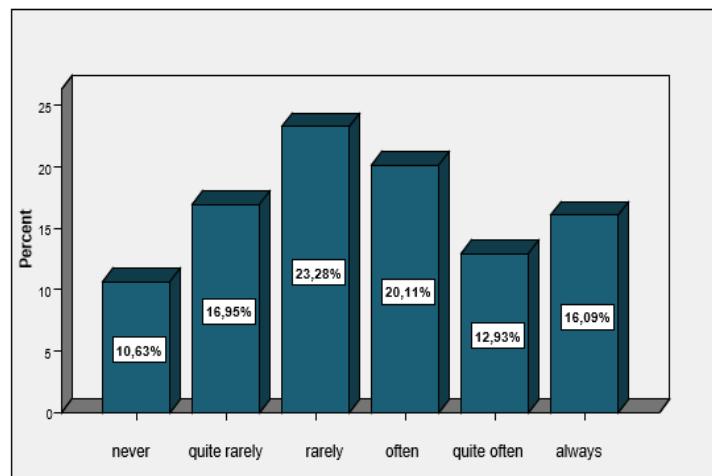


Figure 05. The distribution of responses on the application of mathematical knowledge in practical situations

The frequency of those who always make these connections (16,09%) exceeds the one of those who never make these type of connections with almost 6%. Many (over 23%) are those who rarely link the mathematical notions to the possibilities of applying them in everyday life, and those who make these connections, to a certain extent, are less than 50%.

7. Conclusion

Tackling transfer through errors and obstacles in learning mathematics involves reflection on the following issues:

- By the nature of the subject matter, the mathematical curriculum for the secondary level has a continuous feature, with a “spiral” evolution, in which the construction of concepts at a certain level values the previous mathematical knowledge and anticipates the future one.
- For a great number of secondary level students, the attainment of connections between the previous pieces of knowledge and those in the process of being attained does not represent a component of the Mathematics learning strategy, which is in fact an *obstacle* in the attainment of authentic knowledge (based on operationalizing and *transfer*). Thus, the acquired mathematical pieces of knowledge remain fragmented and isolated, more often than not without significance (“unproductive”), energy consuming for retention and restitution in evaluation situations, far away from their integration in a field of knowledge.
- Math teachers should explain more the relations that can be established between the mathematical pieces of knowledge from the different levels of conceptualization. The intra- (and inter-) disciplinary transfer is a basic mental activity for the construction of the mathematical knowledge, and it has to be learned in school, by means of specific startegies, carefully projected.
- Without actual diversified graphic support, the representations of students upon the studied concepts are frequently reduced to the figural models which the teacher has employed when teaching and this has negative effects on the degree of information operationalizing reducing their possibility of transfer.
- In learning Mathematics, great importance is given to making connections between pieces of knowledge (transfer), at the level of the discipline (connections among different mathematical pieces of knowledge), as well as at the interdisciplinary level (between mathematical knowledge and other fields of knowledge). Even though this aspect of learning should be more explicit during teaching, it is frequently considered the students' concern. They are not always prepared for it, thus it is attained sporadically and to a low extent in relation to its importance. As a consequence, in the absence of such transfer, mathematical knowledge remains isolated, is not integrated into the student's field of knowledge, lacks flexibility, operability and functionality.

In conclusion, *the absence of transfer is an important generating source of obstacles in learning mathematics.*

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