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Evaluation of the Effect of Mathematical Routines on the Development of Skills in Mathematical Problem Solving and School Motivation of Primary School Students in Abitibi-Témiscamingue

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Abstract
In recent decades, the dropout rate in Abitibi-Témiscamingue is a worrying phenomenon. An analysis of ministerial examination results identify that students in Abitibi-Témiscamingue have specific difficulties with mathematical problem solving tasks (MELS, 2014). Among the activities that develop those skills, the daily routines in mathematics seem to be a preferred pedagogical approach. The main purpose of this project is to evaluate the effects of doing daily routines in mathematics on two indicators of student success in school : problem solving rates and school motivation. In order to realize the objectives of this research, we implemented two types of activities in classrooms. At first, we used board games in order to develop childrens problem solving skills. Second, we used daily routines, which imply five types of logic challenges. To meet those objectives, a pretest-posttest, with unequivalent control groups, was implemented. The results show that daily routines in mathematics help to develop problem solving skills of the students in Abitibi-Témiscamingue. Moreover, those routines have an effect on the extrinsic motivation of primary school students in Abitibi-Témiscamingue.

1. Problematic
In recent decades, the dropout rate in Abitibi-Témiscamingue is a worrying phenomenon. In this region, the dropout rate is around 10% higher from the province's mean [1]. Recent ministerial data shows that the gap between girls' and boys' rate of diplomation is the greatest in the province of Québec. In fact, in this region, the boys' dropout rate is around 2.5 time greater than the girl's rate. In 2010-2011, the dropout rate for boys has reached its peak with a 26.6% level [2]. An analysis of the ministerial examination results identify that students in Abitibi-Témiscamingue have specific difficulties with mathematical problem solving tasks [3]. To complement this data, the Observatory of the Abitibi-Témiscamingue notes that students of this region demonstrate a lack of school motivation [4]. By the challenge they bring, the tasks mobilizing logical challenges is a favored avenue in order to intervene with boys and girls of primary schools [5]. Moreover, by the competitive nature it brings, the daily game routine, which implies mathematic components, appears to be a good way to prevent school failure of boys at risk [6]. With the aim of preventing school difficulties, it is important to intervene early in the primary school curriculum [7].

1.1 Purpose and research questions
There are two purposes to this research: (1) to evaluate the effects of daily mathematical routines, which imply logical challenges on school motivation and mathematical problem solving abilities of 3rd grade children who live in Abitibi-Témiscamingue, and (2) to evaluate the effects on those variables on daily routines, which involve mathematical games.

The research questions of this project come from the objectives presented above:

- What are the effects of daily mathematical routines, which involve logical challenges, on school motivation and mathematical problem solving abilities of 3rd grade students who live in Abitibi-Témiscamingue?
- What are the effects of daily routines, which involve mathematical games, on school motivation and mathematical problem solving abilities of 3rd grade students who live in Abitibi-Témiscamingue?

2. Theoretical Framework

This research is situated within the constructivist theoretical literature, specifically within cognitive and social constructivism. The cognitive constructivist theory is centered on providing learning contexts and platforms that enable learners to generate experience-based knowledge, individually or through interaction with others [8]. Social constructivism draws on the work of Vygotsky [9][10], Wertsch [11] Wenger [12] and others who conceptualize learning as a co-constructed product of social interaction, through collaborative problem solving, peer engagement and mentorship. Both forms of constructivism are oriented around the belief that effective learning is highly contextualized within authentic (or models of authentic) settings that involve realistic approaches to problem solving.
In order to operationalize, two concepts are relevant to define: problem solving and school motivation.

Problem Solving

In regard of the concept of problem solving, we mean by problem a situation where a person pursues a goal and does not know immediately the scenario of resolution to achieve this objective [13]. Moreover, according to Poirier [14], the problem must be a reasonable challenge and be accessible to the person. The person facing a given problem needs to develop a series of actions that is within range. To this end, Bair, Haesbroeck and Haesbroeck [15] define problem solving as a research exercise which is, for those who attack it, a "challenge" which mobilizes his abilities and comprehension skills. This approach enables the implementation of knowledge in new situations.

School Motivation

Romando [16] defines school motivation as an internal drive that activates behavior and gives it direction. The term motivation theory concerns the processes that describes why and how human behavior is activated and directed. Vallerand, Pelletier, Blais, Brière, Senécal and Vallières [17] identify four components of school motivation: 1) amotivation, which is a lack of motivation, 2) intrinsic motivation, which refers to the fact of undertaking an activity for the satisfaction and pleasure of doing so 3) the identified extrinsic motivation, which consists of behavior regulation by the free choice a person makes that identifies the reason for its choice; the consequence is external and not linked to pleasure and satisfaction, and 4) introjected extrinsic motivation, which involves behavior regulation by internalized control sources from the person; these control sources exert pressure on the person.

3. Methodology

3.1 Design and Sample

In order to answer to the research questions, we used a pretest-posttest quantitative design. Three groups took part in the design: two experimental groups and one control group. The first experimental group (N=48) participated in a school program which involved daily routines in mathematics (1-Sudoku, 2-chess, 3- find an intruder in a group of objects, 4- match replacing, 5- solving adaptation of Raven's matrices). The duration of the program was two months. The children from the second experimental group had to play mathematical games two hours per week (N = 33). The intervention lasted two months. Finally, the students from the control group didn't participate in a particular school intervention (N = 38). All the participants of the study were 3rd grade students from the region of Abitibi-Témiscamingue (Québec, Canada).

3.2 Variables of the Study and Evaluation Instruments

We used two variables to conduct this study. The first variable of the study was school motivation. This variable had four distinct components: intrinsic motivation, amotivation, identified extrinsic motivation and introjected extrinsic motivation. To evaluate this variable, we used a tool developed by Vallerand et *al.* [18]. The instrument was composed by 12 different questions. The Cronbach's alpha is established at 0,80.
The second variable of the study was the mathematical problem solving abilities. In order to evaluate this variable, we built ten word problem solving statements. According to the Théorie des champs conceptuels

of Vergnauld [19], the statements evaluated three senses of addition and two senses of multiplication. The scale of Voyer [20] was used to evaluate children's score on this dependent variable.

3.3 Analysis

In order to compare the three group's score on both dependent variables, we used a covariance analysis (ANCOVA). Those analyses were made on every component of school motivation and every sense of addition/multiplication fields.

4. Results

The results showed that girls in the first experimental group developed their school motivation. The effects were perceived according to an introjected extrinsic motivation ($F= 5{,}092;\ p \leq 0{,}05$). A look at Cohen's indicator shows that the effect size of solving logic challenges in mathematics with an introjected extrinsic motivation is important ($\eta 2 = 0{,}134$) For the second experimental group, we observed that children developed their ability to solve mathematical problems that involve the *transformation* sense of the addition field ($F= 5{,}917;\ p \leq 0{,}05$). The effect size analysis shows that playing games that involve mathematic components has a moderate impact on the development of the ability to make additions of the *transformation* sense ($\eta 2 = 0{,}067$). Moreover, the results show that boys who play mathematical games at school have better results on the introjected extrinsic motivation test ($F= 4{,}056;\ p \leq 0{,}05$). The analysis of Cohen's indicator shows that playing mathematical games has an important effect on boy's introjected extrinsic motivation ($\eta 2 = 0{,}084$).

5. Data Interpretation

Based on the data obtained, we note that participation in a school program where children have to solve mathematical challenges on a daily basis helps them develop their introjected extrinsic motivation. The routines that vary mathematical tasks every day are more motivating for girls and the routines which involve mathematical games are more likely to develop introjected extrinsic motivation for boys. Those results show that daily routines in mathematics, that involve playing games or solving different logical challenges, acts as an external component of school motivation for 3rd grade children. Moreover, we observe that our activities do not allow to get students to solve mathematical tasks for the sake of doing so.

On the other hand, playing mathematical games in school can only develop the sense *transformation* of the additive structures. This sense is characterized by a transformation or a change in time that acts on an initial state to produce a final state [21]. To explain these results, we hypothesize that the practice of mathematical games specifically solicits actions that lead to effect change or to transform data. Consequently, *transformation* sense of additive structures is especially developed by the act of playing games at school.

6. Conclusion

Finally, after conducting this study, we firmly recommend educators to implement activities involving a daily routine of logical challenges or free practice of mathematical games. These activities can contribute to develop the introjected extrinsic motivation of 3rd grade students and their skills in solving problems involving specifically the sense *transformation* of the addition field. This study was conducted in Abitibi-Témiscamingue, but it could be replicated elsewhere.

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