INTELLECTUAL AMPLIFICATION AND OTHER EFFECTS "WITH", "OF" AND "THROUGH" TECHNOLOGY IN TEACHING AND LEARNING MATHEMATICS

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ABSTRACT

In this paper we invite to discuss about the effects that technology produce in the cognitive capacities and even in the affective process of the students during mathematical problem – solving situations. We use the study made by Salomón and Perkins, D. [1] and our own experience to deepen in the analysis of these effects.

1. INTRODUCTION

The intelligent dialogue with computational tools requires that cognitive functions should be distributed in an optimal way between student and tool. In the old paradigm, teaching of mathematics was based on a repetitive practice until perfecting certain knowledge. With the use of technology this practice should be change in an intelligent way, therefore we should get a better understanding of the effects that technology causes in the cognitive processes.

In [1] Salomon G. and Perkins, D. in a wider context of application of technology wonders if it expands our cognitive capacities in any fundamental sense. To give answer to this question they introduce the concepts of "*effects with technology*", when it is used to improve the intellectual performance while one is operating the tool; "*effects of technology*", when the use of technology may leave cognitive residues which enhance performance even after one stops to use it; and "*effects through technology*", when the technology sometimes does not just enhance performance, but fundamentally reorganizes it. These effects have different timelines, frequency of occurrence and magnitudes of impact.

2. *EFFECTS WITH TECHNOLOGY.*

When a calculator or a computer is used by student in the resolution of mathematical problems, for example during an examination, it is established an intellectual partnership so that cognitive functions are distributed among the student and the tool. This is what it's called "effects with technology".

This partnership implies a division of labour and the interdependence typical of the interaction with tools, which mean a skilfully operation as contrasted with machines that usually work without too much involvement on a human part. The basic objectives are to free the student from distractions of lower - level cognitive functions, for example cumbersome or repetitive calculations, long algebraic manipulations, etc., and to provide that the tool is used in mindful way that benefit from the partnership, it is likely to lead to enhanced intellectual performance. Maybe this effect is the one that more controversy causes in teaching and learning of mathematics. There is not consensus on, for example, what should be considered lower - level cognitive functions or what previous knowledge the student needs in order to interpret calculator or computer's answer correctly. On this respect J. B. Lagrange in [2] writes:

"*It is clear that we have to reflect on the prior algebraic knowledge required. Students do not necessarily need strong procedural abilities but obviously should not be lacking some key knowledge of algebraic structure*".

On the other hand, the establishment of this partnership doesn't happen immediately and sometimes during the first examinations a poorly efficient use of the tool is observed, becoming in occasions in a distracting element.

3. *EFFECTS OF TECHNOLOGY.*

"Effects of technology" concern effects, positive or negative that persist without the technology in hand, after a period using it. In the positive case there are acquisition of new knowledge or abilities and it is achieved the conceptualization [2]. We say, in this case, that the tool possesses not just a practical value, but rather an epistemic value too. The negative effects can appear, for example when it is generated an excessive dependence with the tool, getting lost abilities which are considered indispensable. Again, there is not here consensus on the abilities which should be considered indispensable and cannot be substituted by others related with the technology.

Since technology appeared in mathematics education, there has been an intense debate about what should happen to paper-and-pencil techniques, some authors have tried to identify list of basic skills that mathematics educators would agree are necessary for students to know how to perform by hand, but this is still an unresolved topic. The teaching and mathematics are simultaneous changing but the mathematical curriculum take a time to change, for this reason teachers and students will live for a while in an ambiguous situation about the required paper-and-pencil skill.

In any case, the work with computational tools leaves a mark in the student. In the first place, student should develop suitable skills to organize thought and needed psychomotor abilities for an effective working with the tools, and in the second place, he should learn concepts and precise mathematical definitions so that an appropriate dialogue with the tools exist. For example, calculator represents functions, expressions, equations, lists, vectors, points and matrix in a precise way, highlighting this way their differences and the type of operations which can be used with these mathematical structures.

4. EFFECTS THROUGH TECHNOLOGY

The authors Salomon, G. and Perkins, D. uses the concept “effects through technology” when its influence is radically transformative i.e. when the technology fundamentally restructures and reorganizes its domain of action.

In the case of our interests the computational tools in a radical way have modified and continue modifying the mathematical work. *Experimental mathematics* [3] itself arises from the "effects through technology".

These radical changes caused by use of computational technologies can be noticed in many aspects of the mathematical research and education. For example, almost all the publications in mathematics and teaching texts followed a faithfully order of stages that we could denominate traditional teaching, which included the following strict steps:

- Result's formalization.
- Formal deduction.
- Informal deduction (informal understanding of concepts).
- Analysis.
- Visualization.

Teachers used these steps applying them in their classes. It was presented first with strict rigor a formalized result (theorem). Then it was considered as something indispensable and immediate to carry out a formal proof (formal deduction). Often and with the objective of explaining meaning and content of this formal proof, it was tried to present an explanation by means of an informal deduction which included an analysis of the steps of the formal proof that could justify reasons for that deduction. Finally it was attempted to visualize theorem by means of examples which allowed particularizing the generalization of the theorem.

The incorporation of mathematical software and the appearance first of programmable and numerical calculator and specially later with the graphical and symbolic calculator has allowed to achieve, up to now, a timid attempt to recover the self - exigency to conjecture before generalizing, to experiment before proving, to “see” and “feel” that the problem has been more deeply understood before trying to emit a final statement or to formulate a definitive property, to feel we participate in the creation of a result, “to doubt” or “to believe” in results obtained by computational tools which at first sight seems to be fast and perfect, but that usually present new and unexpected challenges which in turn suggest diverse interpretations and multiple applications.

The experimental mathematics approach [3] suggests to reverting the order of previously mentioned stages. The primary target to teach mathematics is not simply to generate correct answers to the problems, but to teach to mathematically think. The technology for educational purposes is a fundamental piece to allow this objective and its correct implementation would have to involve five stages ordered in the following process of mathematical thought:

- Visualization.
- Analysis.
- Informal deduction
- Formal deduction.
- Result's formalization.

This order, which has taken time settling down in mathematical education, it is in full agreement with the implications of Bruner's theory [4], that emphasizes the importance of learning by discovery, motivating students to discover relations between concepts and to construct propositions based on their own discoveries.

5. SOME OTHER EFFECTS OF USING TECHNOLOGY

In mathematical problem – solving situations affective and social factors as much part of the student's thinking and behaviour as are cognitive factors. In this context we notice some additional effects of the technology.

In our didactic experience at Universidad Diego Portales we have implemented the use of a powerful symbolic and graphic calculator [5] in the cycle of courses of mathematics for engineering. This calculator provides us with a set of useful applications and with a basic programming language. This implementation has generated an interesting debate on its influence on different aspects in teaching and learning mathematics. Some students, which participated in this didactic experience, manifested that they didn't feel alone when they faced the resolution of mathematical problems with a calculator in their hands. As it was expressed by one of the teachers:

"*This student is not alone in front of the problem; he is accompanied by the hundred of programmers that necessarily went for him to the theory to develop the programs that solve the outlined mathematical problem*".

6. REFERENCES

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