REACTION TO "A META STUDY ON IC TECHNOLOGIES IN EDUCATION; TOWARDS A MULTIDIMENSIONAL FRAMEWORK TO TACKLE THEIR INTEGRATION"

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1. Global reaction

The work of Lagrange, Artigue, Laborde and Trouche is impressive. The French team surveyed an immense number (662!) of publications on technology use in mathematics education. For a researcher in this field, it is very fascinating to read this synthesis of such a massive corpus of literature. The virtue of the study is that it helps in identifying trends, developments and progress in research into technology use in mathematics teaching and learning. Looking back at the work of the last decade enables us to better see the headlines, the dead ends, the topics 'in fashion' and the issues to be elaborated. Also, as the authors indicate, the described framework can help innovators or researchers to characterise a project or a study and to position it in a broader perspective. To me, those are the most important merits of this study.

However, some questions can be raised. My first 'question mark' concerns the aims of the study. Related to this is the point of the dimensions that the study wants to identify. What exactly are these dimensions and what are they used for? Furthermore, depending on the aims of the study, the value of the conducted cluster analysis can be questioned. To summarize, I feel that the quantitative part of the study is too far away from the concrete integration of technology in the classroom to contribute to the 'understanding of integration' that the authors are searching for.

Let me address each of these issues briefly and then come back to the theory of instrumentation.

2. The aims of the study

The first issue I would like to raise is that of the aim of the study. What are the goals of the research presented here? In their introduction, the authors mention their concern about the discrepancy between promising Information and Communication Technologies (ICT) and low actual integration in the classroom. 'Our aim was to build tools for the understanding of integration …'. Further on in the paper, two aims are distinguished: building a methodology for analyzing research, and identifying trends. I think these last two goals are achieved, although maybe it is better to speak about an investigation of diversity than about a synthesis. However, the study, as it is presented here, did not succeed in contributing to the understanding of the integration of technological tools. The subject of the study, as I see it, is not the integration of

technology in the mathematics classroom, but *literature* on this issue. In this sense, it is really a meta-perspective, as is indicated in the title of the paper. The paper is far away from the mathematics classroom; it is a survey of literature on the teaching and learning of mathematics using ICT. Of course, it is quite legitimate and useful to serve a meta-goal. But as long as results and details of research projects are not considered, a cumulating understanding of what happens in the heads of the students cannot be expected.

3. What are dimensions?

The second point, the meaning of the word 'dimensions', is related to the question of the aim of the study. To me it remains unclear what exactly is meant by a dimension. Is it 'a perspective', is it 'an approach', is it set of questions in the questionnaire that was used in the analysis? If I look at the eight dimensions that are defined and were applied to a subset of 79 papers, it is not clear to me what they stand for and if there are any relations between them.

Furthermore, the way in which the dimensions are identified by the researchers is not explained. I regret that the researchers did not (explicitly) take their impressive expertise in this field as a point of departure for such an identification in order to compare this with the massive data they gathered. The only dimension that is discussed somewhat in detail, the dimension of the 'problematiques', seems to be related to the CAS research where it is derived from. The question arises whether dimensions inferred from studies concerning CAS are also valid for research into technology in education in general. Nevertheless, the identification of the most important aspects or themes that play a role in the integration of technology in the mathematics classroom is an interesting goal.

As far as the development of research is concerned, I recognize two of the mentioned trends from my personal perspective:

- The trend from a rather naïve and optimistic perspective ('technology improves teaching and learning') to a view with more nuances and with attention to the complicating aspects of technology use, the pitfalls as they are mentioned in the title of this research forum. The presentation of Hershkowitz and Kieran provides a nice example of this approach.
- The development of research into technology that stands more and more in the tradition of research on mathematics education in general. The presence of a constructivist theoretical framework in many studies, which is mentioned by the authors, illustrates this.

4. The cluster analysis

After the dimensions were identified, they were made operational in a questionnaire. The 'instrumental' dimension that is elaborated in the paper illustrates some of the

difficulties with this. For example, the question q5 addresses the instrumentation process over time. My impression is that in the papers that are discussed, the time element concerns the question of efficiency and time savings, which is in my opinion not relevant in the instrumentation process; more important are the changes in student behavior over time. For example, it is not clear what the papers cited in cluster 1 have to do with instrumentation. Also, the role of time in the paper of Mayes in cluster 3 is not made explicit. I was also surprised to see that the three clusters that are described as informative together only contain 28 out of 79 papers.

The questionnaire is applied to a second stage corpus of 79 papers. It would have been interesting to know a bit more about the way the team selected the second corpus papers out of the first corpus. Of course one can't explain all the details in a paper like this, but I would appreciate having some more information on the criteria for this crucial selection.

5. The relevance of instrumentation

The exemplary partition of the instrumental dimension reveals the background of the authors: they have contributed much to the development of the concept of instrumentation of ICT tools. In my perception, the relevance of this theory is that it can help to interpret and to understand the behavior of students using technology. The first paper of this research forum, presented by Hershkowitz and Kieran, can serve to illustrate this.

In the contribution of Hershkowitz and Kieran, students use the linear regression procedure on a graphing calculator to fit a line through five data points that were calculated. The underlying algebraic relationship between the variables, however, was non-linear in some of the cases. Apparently, the students mastered the (non-trivial!) technical part of the instrumentation scheme. However, they are unaware of the mathematical meaning of this command. The accompanying mental scheme of what it means to apply a linear regression and when it is an appropriate technique seems to be lacking.

Thanks to the graphing calculator, teachers may be inclined to use regression with their students, maybe even for fitting a line through two given points, thus freeing the students from some algebra. However, if the teachers forget to pay attention to the limitations of the method and to the difficulties of curve fitting, the resulting instrumentation scheme will be incomplete. I suppose many teachers of a curve fitting course have experiences with students obtaining a perfect fit through n given data points using a polynomial of degree (n – 1) without wondering if the algebraic model is appropriate. In my opinion, the dialectic relationship between ICT technique and mathematical concept, the interplay between the two, is very important in the theory of instrumentation and in the understanding of student behavior while using ICT.