Solid findings in mathematics education: What are they and what are they good for?

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This paper presents the contributions of the participants at the CERME10 panel, as well as some of the questions raised during the discussion. Our main aim is to examine the notion of solid finding in mathematics education, the theoretical and methodological assumptions underlying their establishing and the degree of agreement (and disagreement) they provoke. We will consider their possible utilities and weaknesses, even jeopardies, taking into account two different standpoints: how solid findings are identified and what kind of common ground they rely upon; what are solid findings for, how can they be useful and what could be their risks or adverse effects. The panellists will adopt different perspectives on the topic, focusing on the specific selection of solid findings proposed by the Committee on Education of the European Mathematical Society, approaching the problem of the methodologies and use of psychometric models; questioning the use of evidence in policy development and curriculum evaluation.

Keywords: Mathematics education, solid findings, criteria, empirical proof, concept images, measurement, reliability, validity, invariance, math anxiety, statistics anxiety, PISA.

Solid findings in mathematics education: A necessary discussion

Marianna Bosch

Proposing to collectively discuss on 'solid findings' in mathematics education at CERME10 was certainly motivated by the initiative of the Education Committee of the European Mathematical Society (EMS) to start publishing a series of articles on 'Solid findings in mathematical education' in 2011 (http://www.euro-math-soc.eu/ems_education/education_homepage.html). This can be interpreted as an audacious attempt to establish a stable account of our young discipline, which otherwise might appear as made of too diverse principles, approaches and perspectives. It is thus supposed to facilitate the approach by people from the outside, especially mathematicians and teachers, by giving more visibility of the type of questions approached and the results obtained. Inside the discipline, it also appears as an effort to organise and elaborate a provisional common hard core (in the sense of Lakatos) of sound and relevant knowledge, without denying the provisional and dynamic nature of the considered findings.

Taking the EMS project and its products as initial motivation, the aim of the panel is to examine the notion of solid finding, the theoretical and methodological assumptions underlying studies on solid findings and the degree of agreement (and disagreement) they might provoke. We propose to consider the possible utilities and weaknesses, even jeopardies, of the reports on solid findings, taking into account two different standpoints: (1) how solid findings are identified and what kind of common ground they rely upon; (2) the purpose of solid findings, their potential utility, and also their possible risks or adverse effects.

The aim of the panel was thus to open a debate on controversial questions like:

(1) What is a solid finding in Mathematics Education? What criteria are used to select them? Who decides whether a finding is solid or not? Are solid findings linked to specific methodologies, theories or approaches? Can they be contested and how? What kind of evidence is required? Is it the same kind of evidence for the different 'findings'?

(2) What is the purpose of identifying solid findings? What are they for? How can they be useful? Are they necessary for teacher education? Could they help to give more visibility to our field and to negotiate with educational decision makers? Can there be a risk of disseminating false 'weak' solid results instead of disseminating the persistent questions addressed from research in mathematics education – which do not always coincide with those raised by the actors of the educational system (teachers, students, parents, decision makers, etc.)?

During the discussion among the participants at the panel session, the question of the diversity of theoretical perspectives was raised on various occasions. It is clear that solid findings are always anchored in a given research approach or paradigm (a set of close theories sharing the main theoretical principles or assumptions). Agreement on solid findings thus supposes agreement on these main assumptions too. This does not seem to be – at the moment – the historical situation of the research community in mathematics education, where a diversity of approaches coexists without a common shared ground. Not only the type of results provided by these approaches are different, but mainly the type of research questions asked, the methodologies used, and even the empirical units of analysis considered. If solid findings are presented without mentioning the approaches where they have been produced, we run the risk of interpreting solid findings as if they came from an a-theoretical perspective (or from a fully shared one), which is in fact a way of giving preponderance to the already dominant approaches in detriment of the less disseminated ones.

Other questions related the issue of solid findings to the problem of the dissemination of results. If solid findings should be closely contextualised within a given theoretical framework – or research perspective –, how to make them accessible to people not knowledgeable of the framework? To what extent, and under what conditions, could solid findings be extended to include frameworks? The question varies of course if we think about disseminating research outcomes outside the field, or about highlighting what are seen as important milestone in the evolution of the field, for instance to build the basis for productive debates.

Furthermore, participants also indicated that it is important to avoid not only taking the theoretical 'load' of solid findings for granted, but also to pay attention to the *values* they implicitly carry on, for instance, about the purpose of education, the purpose of research on mathematics education or

about the corresponding specific epistemology or conception of science. For instance, the choice of the term 'finding' seems related to a somewhat naturalistic perspective – the scientific discovery of a pre-existent reality –, while other options such as 'claims', 'proposals' or 'questionings' (in the double sense of raising questions and questioning the status quo) would entail other connotations. In this sense, maybe the dimension of problematizing can also be a possible direction to work with.

In fact, one of the questions from the audience addressed the issue of the relationships between solid findings, persistent phenomena and educational problems: Are solid findings restricted to phenomena that persist? Is it also possible to have a solid finding that eliminates a problem? In other terms, because advancing research also modifies our ways of problematizing reality, solid findings can also make some problems appear as simple difficulties that can be overcome, or as consequences of other factors to be approached. In the other sense, a solid finding can also consist in the awareness that a problem has not solution – at least in the framework where it is formulated.

The establishment of solid findings as such was also referred to by some participants. Some of them wondered if it is possible to identify some steps to help establish solid findings and build upon them more systematically. Others asked about efficient ways of guaranteeing cumulative research efforts, such as the replicability of the solid findings, which was proposed as a possible research avenue to pursue. One should not see naivety in this kind of demands – as if we were asking for 'recipes' –, but on the contrary, interpret them in terms of a reflection on the research methodologies followed (in terms of validity, truthfulness, reproducibility, etc.) and the level of exigence put on them. To enrich the debate, some participants provided related materials or counterexamples to this kind of reflexion, such as the U. S. webpage "What Works in Education" (http://ies.ed.gov/ncee/wwc/) or the special issue of the International Journal of Research & Method in Education (2016) *Is the Educational 'What Works' Agenda Working? Critical Methodological Developments*, including a paper on review procedures to optimise reviews' impact and uptake (Green, Taylor, Buckley, & Hean, 2016).

The three contributions that form the core of this paper address some of the issues raised from very diverse – and complementary – perspectives. Tommy Dreyfus, a member of the Education Committee of the EMS and co-author of some of the 'solid findings' articles, provides a very interesting account of two moments of reflection of our community around the issue of 'results' or 'findings' in mathematics education, and their related projects. He also presents two examples of 'solid findings', showing the criteria used to identify them and also some of the limitations of the efforts made. He argues for a collective effort toward the products of more systematic reviews on different topics or approaches, as a way to increase the impact of research outside the field but, also, to "establish and organize mathematics education as scientific discipline and to determine where we come from, where we are and where we might go as a research community". From a completely different side, Caterina Primi, an expert in the field of quantitative educational research, addresses the methodology problem – measurement tools to support rigorous research designs – for findings to be 'solid' or, in statistical terms, 'robust', 'reliable' and 'unbiased'. Even if the example taken and the questions raised are only related to quantitative methods – where statistical tools are more commonly applied –, the reader can do the mental exercise of transposing them to qualitative as well as theoretical studies to see how demanding the research work to make knowledge develop can be. Finally, Gerry Shiel, National (Ireland) Project Manager for the OECD PISA 2015 Study,

tackles what can be called the 'impact issue' of educational research, considering the PISA phenomenon, which is maybe the source of the most practical and political pressures nowadays in almost all countries. The relationships between 'solid finding' and *evidence-based decision making* provides a rich paradigmatic example and reminds us how intricate is the situation, especially when raw data is proposed without any protection from the procedure followed to generate it and the theoretical framework, including political ideologies, that underlies its generation.

To end this introduction, let me quote the British sociologist Martin Hammersley (2011) who, in his book on methodology, notes how extremely demanding it is to achieve the 'threshold of likely validity required by academic work' (p. 8). After presenting 'dedication', a 'heightened sense of methodological awareness' and 'objectivity' as important virtues for the researcher, the author recalls that, besides these individual virtues:

> [The] collective character of enquiry places additional obligations on researchers, as regards how they present their work, how they respond to criticism and how they treat the work of colleagues. In large part, what is required is that academic research takes place within an enclave that is protected from the practical considerations that are paramount elsewhere. […] In other words, academic discussion must be protected from political and practical demands, so that the consequentiality of proposing, challenging, or even just examining particular ideas or lines of investigation is minimised. […] [While] the 'findings' of particular studies should be made public within research communities, they should not be disseminated to lay audiences. What *should* be communicated to those audiences, via literature reviews and textbooks accounts, is the knowledge that has come to be more or less generally agreed to be sound within the relevant research community, through assessment of multiple studies. (Hammersley, 2011, p. 10)

I am not sure if the field of mathematics education has already reached a sufficient level of development to agree on what can be globally accepted as sound and relevant knowledge, and thus to identify, elaborate and disseminate 'solid findings' to lay audiences. However, I am certain that the community of research in mathematics education is mature enough to initiate a productive debate on this, as a way to make different research perspectives interact in a productive way. The effort of gathering, summarising, organising, and discussing the research produced about certain big questions or issues – as the one undertaken by the EMS Educational Committee – appears nowadays as an endeavour that cannot be postponed.