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Mathematics described proficiency levels: connecting psychometric and teaching analyses

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Introduction

Large scale assessment in education often aims at measuring proficiency in subject areas, thus considering latent variables that are not directly observable but defined through a theoretical framework and operationalized through standardized tests. For each subject area, a numerical test score (proficiency score) is typically computed in order to locate the students on the variable continuum (learning metrics or proficiency scale) defined by the test items, i.e. the proficiency score quantifies how much of the measured variable (for example mathematics ability) is present (Turner, 2014). Reporting test results only in terms of numerical test score, however, does not provide substantial information on what students typically know and can do. A substantial description of the location along the proficiency scale is needed in order to support practitioners in interpreting test results and in order to convert them into effective teaching practices (van der Linden, 2017).

In the last years a growing number of national (e.g., National Assessment of Educational Progress, MEETS NAEP GUIDELINES) and international (Program for International Student Assessment, PISA; Trends in International Mathematics and Science Study, TIMSS; Progress in International Reading Literacy Study, PIRLS) testing programs has been developing descriptive proficiency scales, in order to report test results not only as proficiency scores but also in terms of described proficiency levels. The goal is to illustrate what the scores represent in terms of students’ skills, understanding and competencies (van der Linden, 2017). This goal has been recently pursued by the Italian National Institute for evaluation of the education and training system (INVALSI), that yearly carries out standardized tests to assess students’ achievement in mathematics and reading (i.e. reading comprehension and grammatical knowledge), and to evaluate the overall quality of the educational offering of schools and vocational training institutes.

INVALSI experience

INVALSI returns data as descriptive proficiency levels for reading (reading comprehension and grammatical knowledge) and mathematics, for the first time in the school year 2017-2018. Basing on the INVALSI Reference Framework, and coherently with the National Guidelines for the Curriculum’s goals (MIUR 2012), proficiency scales have been developed through an extensive Rasch item bank, administered by computer based tests (CBT) (https://invalsi-areaprove.cineca.it/docs/2018/INVALSI_tests_according_to_INVALSI.pdf). Five proficiency
levels have been identified considering the distribution on the same scale of both the items’
difficulty and the students’ ability (Desimoni, 2018). The five levels have been described basing
upon the items’ content. The consistency between the item ordering basing on the psychometric
data and the item ordering predicted from theory represents a fundamental aspect for the scale
validity, an issue widely investigated during the scale construction.

The present contribution will investigate the psychometric and qualitative-educational properties of
a pool of sample items (Garuti et al., 2017), from the INVALSI Item Bank, in order to better
investigate this aspect: which are the item properties highlighted from the concurrent psychometric
and qualitative teaching analyses? Beyond an overview of the development of the mathematics’
described proficiency scale, the study will focus on five items, of an increasing level of difficulty
(scaled from 1 to 5), and referring to same content (Numbers) and to the same learning goal
(Operation between numbers and numbers ordering), in order to identify the typical item
characteristics determining its placement within a level. Specifically, which are the cognitive
obstacles that students need to overcome to pass, for instance, from level 3, “link and integrate
multiple fundamental pieces of knowledge concerned with processing, ordering between rational
numbers and representations of mathematical objects” to level 4, “integrate and make connections
between basic pieces of knowledge where the relationships are provided implicitly or derived from
a representation”.

From a practical perspective, we found interesting results, that might be supportive to the
development of new items for the INVALSI Item Bank. Finally, we also discuss potential
implications of our results in the teaching process.

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