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Attitudes towards Physics: Developing an instrument to measure the Physics learning improvement in Italian high school

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Summary. — To assess students' attitudes towards Physics, teachers and researchers need an instrument focusing on the learning difficulties arising from different causes. As is well known in the literature, these difficulties depend on a number of factors deeply involved in the learning process and related with the teaching strategy and methodologies. Considering these main factors as referred to three-dimensional model, we have developed an attitude scale according to the cognitive, affective and behavioral components. The reliability test on a sample of about 500 students in a scientific high school of Trieste (Italy) retained an excellent Cronbach-Alpha coefficient. A brief description of the statistical analysis is reported focusing on the main results from the collected data. The use of this tool is proposed for a more extensive investigation in order to quantitatively highlight which attitudes emerge and encourage the promotion of curricular and orientation activities better calibrated to develop a positive attitude towards Physics.

1. – Introduction

Physics education researchers have created several surveys assess some important aspects for promoting the study of Physics and help students become more expert-like in their beliefs: what students believe that learning physics is all about, which is the best way to learn, which is the confidence in studying this discipline and how they feel when they learn physics [1].

Investigating how students perceive the discipline in their studies we could measure students' self-reported beliefs about physics and their physics courses and how closely these beliefs about physics align with experts' beliefs. This is a practice well known in the English world education system (both at the the high school level and for university courses), but it is not widely experimented yet in the Italian one.

The most known and accredited surveys in Physics Education Research (PER) include:

- Views About Science Survey (VASS) [2],
- Colorado Learning Attitudes about Science Survey (CLASS) [3],
- Epistemological Beliefs About Physics Survey (EBAPS) [4],
- Physics Attitude Scale (PAS) [5, 6].

They ask students questions about how they learn physics, how physics is related to their everyday lives, and how they think about the discipline of physics [1]. For example, students may be asked whether they agree or disagree with statements such as:

- I study physics to gain knowledge that will be useful in my life outside of school;
- A fundamental issue in learning physics is being able to memorize all the information I need to know.

All these surveys are free to use in the English version, and some of them had been translated in other languages but never in Italian ([1]).

2. – An Italian attitude scale

The constant use of an attitude survey in Physics is a way to assess the students' attitudes about the discipline. If they result negative or zero, or weakly positive, this means that it is necessary to promote some changes in the teaching approach according to the indications resulting from the survey shows.

In the Italian experience there are not good practices of educational monitoring, also for the lack of a proper scale for the specific school curricula and tradition of teaching physics.

Therefore we considered very important for us to create *ex novo* an attitude scale reproducing some of the main features of the existing scales in measuring attitudes towards Physics [2-6] but also looking at the experience in Mathematical Educational Research [7-9]. The relevant features of our scale are depicted here:

- robust psychometric properties based on three-dimensional model for an attitude scale [10];
- the way of ranking statements using a five-point Likert scale [11] from "strongly agree" to "strongly disagree", including a neutral point of view for collecting more detailed student opinions;
- the usage of a reversed scoring system for negative statements.

The attitudes have been defined according to three components: affective-emotional, cognitive and behavioral. The affective-emotional component refers to feelings of either liking or disliking for the attitude object (in this case physics as a discipline to be learned). The cognitive component highlights the attitude towards induced processes in terms of construction of concepts, ideas and knowledge. The behavioral component refers to the actions that are put in place aroused by facing the study of Physics.

For each of them we have identified about ten items (listed in the footnote link ([2])).

2˙1. *Testing and validating sample*. – This survey was administered to 467 students of the Liceo Scientifico Guglielmo Oberdan in Trieste (Italy). This high school has three different scientific curricula for studies: Traditional Scientific Curriculum (TSC), Applied Science Curriculum (ASC) and Sports Curriculum (SC). The sample was representative of the population of each curriculum (table I). It is fully disposable in the on line version ([3]) and the students answered using their own devices during school time. We did not collect blank answers or incomplete surveys.

([1]) `https://www.physport.org/assessments/`
([2]) `shorturl.at/egmEZ`
([3]) `https://forms.gle/Xfwfhr53cCantKFDA`

TABLE I. – *Features of the student sample for the scale validation.*

Class year	Student number	M	F	TSC	ASC	SC
I	134	80	54	32%	49%	19%
II	46	22	24	52%	43,5%	0,5%
III	101	45	56	48%	51%	1%
IV	74	39	35	62%	35%	3%
V	112	66	46	40%	38%	22%
I–V (tot)	467	252	215	45%	43%	11%

TABLE II. – *Correspondence of mean score and attitude indicator.*

Average score	1,00–1,49	1,50–2,49	2,50–3,49	3,50–4,49	4,50–5,00
Attitude indicator	negative	towards neg.	neutral	towards pos.	positive

2˙2. *Data analysis*. – The data had been analyzed to determine the reliability, the validity, and the internal consistency of the scale. The internal consistency as a whole (and also for each component as a control parameter) was computed using the Cronbach alpha coefficient [12]. To be more confident we have compared the standardized Cronbach alpha based on the correlation matrix with the corresponding unstandardized one based on the covariance matrix [13]. For a more detailed scale validation it could be interesting to proceed with factor analysis by an extensive statistical process, even if the three-dimensional model adopted here already introduces a factorization of the scale: as a first step along this way we have determined the Sample Adequacy Measure (MSA), calculating the Kaiser-Meyer-Okin coefficient (KMO), required to proceed with the factorization [14, 15].

3. – Results and discussion

The measure of the internal consistency of the proposed scale has given the excellent value of 0.9 (with average value 0.89 even after making the analysis of the inter-items correlation effects by removing less correlated items) according to the thumb rule recommended by the literature [14].

Also the KMO coefficient is satisfactory, showing an attitude scale that could be factorized (KMO coefficient = 0.989) [16], expected using the three-dimensional model and confirming the homogeneity of our instrument [15].

Once the scale has been validated, we made a statistical descriptive analysis of our data based on the average value of each score item, that correspond to a given attitude trend as in table II.

We obtained some interesting results, summarized in the following items:

- the students change their attitudes during their studies: they shift from a weakly positive attitude to a neutral one in the last year of their Physics course;
- this trend is highly confirmed by gender differences. Female students show a more impressive discipline disaffection in all the curricular years with respect to male students;
- the students are considerably aware that a successful learning depends on different factors, but in any case they would like to practice more laboratory activities and afford multiple representations of physics situations.

4. – Conclusions

We propose a new attitude scale adequate to the Italian Physics courses in high school to promote an instrument to measure the involvement of our students in the study of this discipline. The survey is a good way to get a quick feedback from the learning step-point and to monitor the effects of the teachers' approach and methodology. The validation of the scale gives the confidence to use this effective instrument in terms of its psychometric properties to measure the students attitude towards physics. All teachers could use it as a thermometer of the effectiveness of their own educational activities.

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