

High school students' attitudes towards physics and physicists: An analysis based on multiple correspondence analysis

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Summary. — In this paper we describe high school attitudes toward physics using Semiotic Dynamic Cultural Psychology Theory (SDCPT). A View of Physics questionnaire was used to collect data about the views on physics and physicists with 337 high school (16–18 years old) students. Data were analysed through Multiple Correspondence Analysis and Cluster Analysis. We identified four basic generalized meanings of physics. In particular, it turned out that students see physics as either: a) interesting and important for a technology-based society; b) quite interesting, but badly taught at school and not completely useful for society; c) difficult and irrelevant for society; d) fascinating and important to study at school, but with an underrated value for society. Our study supports the use of the SDCPT framework to refine interpretative models of students' motivation towards physics and develop new ways of teaching physics at secondary and university level.

1. – Introduction and aims

The purpose of this study was to investigate high school students' attitudes towards physics using the Semiotic Dynamic Cultural Psychology Theory (SDCPT). In the SDCPT theoretical perspective, psychological processes consist in sensemaking processes of the world that, in turn, shape experience [1]. A sensemaking process is an interpretation process that links the emotional level of experience with the formal level of cognition [2]. Such process is guided by generalized meanings, namely, intuitive, not rationally justified assumptions concerning what the world is and how it works. These assumptions include opinions, values, beliefs, attitudes concerning facts and objects of the social and physical world and represent generalized functions of individuals' sensemaking of the world. In this perspective, sensemaking is inherently social, embodied, contextual and situated. Due to

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their implicit nature, generalized meanings are not directly observable, but, rather, they are embedded in a given cultural milieu that is the environment in which individuals' feelings, thoughts and social agency are grounded. To analyse a cultural milieu, the SDCPT models the sensemaking process as a dynamics of sign transition within a semiotic space [3]. On such empirical base, generalized meanings can be used for mapping and explaining variability in the individuals' manifestations of representations embedded in this cultural milieu. Such manifestations represent how individuals interpret their experience through the mediation of the generalized meaning with which they are identified [4]. As a consequence, SDCPT allows to investigate how individuals differ in their behavioural manifestations depending on the generalized meaning they identify with. Overall, the focus on sensemaking process in the SDCPT allows to consider the personal identity and its aspects not as a static entity, but as a semiotic process of construction and negotiation in becoming [5]. Using the SDCPT perspective, we will model the physics culture as a semiotic space, characterized by certain set of generalized meanings. As a consequence, we will assume that individuals can be typified in terms of these generalized meanings and that they differ in their manifestations towards physics depending on the generalized meaning they identify with. We will assume that generalized meanings in physics are informed by school and university experiences, peer interactions, exposure to media communication, family background, utility value and success expectancy, etc. Moreover, generalized meanings of physics will be assumed to affect individuals' behaviour, for instance the intention to choose physics at undergraduate level. The following research question guided our exploratory study: *What generalized meanings of physics emerge from the characterization of the students involved in this study?*

2. – Methods

2.1. Sample. – A convenience sample of 337 high school students (143 girls, 42.4%) from 30 different schools in a large town in South Italy was involved in the study. Average age was 16.9 ± 1.2 years.

2.2. Instrument and measures. – The analyzed dataset consists in the students' responses to a 36-item Views of Physics (VOP) survey instrument on-line (the students were given 30 minutes to complete the questionnaire). VOP items were selected from previous instruments [6]. The items were expected to trigger the activation of generalized meanings by focusing on a multiplicity of potential cultural functions of physics and physicists, using a formulation that could trigger value-laden views between contrasting positions, in a similar way to what the view-of-context instrument does in SDCPT. We selected items concerning the perceived value of physics in today's society, the recognition of the difficulty of physics, the intrinsic interest in physics, personal relevance to work with physics, the relevance of learning physics at school, the recognition of physicists' role in society, and the value of physicists' careers. For each item, the students were asked to state their degree of agreement by using a 5-point Likert scale. Cronbach's alfa of VOP was 0.87, showing an excellent internal consistency of the items.

2.3. Data analysis. – To answer our research question, we first used multiple correspondence analysis of the sample responses to the VOP instrument. The extracted factors constitute the dimensions of the semiotic space that models the physics as a culture. Then, we performed a hierarchical cluster analysis aimed at identifying emerging response profiles associated with different groups of individuals. The clusterization

TABLE I. – *Cluster of students' attitudes toward physics.*

Cluster	Name of the cluster	% of students
Cluster 1	Ideal value	44.2
Cluster 2	Blurred discipline	35.3
Cluster 3	Hard and irrelevant	10.3
Cluster 4	Practical value	10.2

process was based on the multiple correspondence analysis of responses to the VOP instrument. All the dimensions extracted from the software through the analysis of multiple correspondences were used in the cluster analysis. In agreement with the SDCPT framework, we considered each cluster as a marker of a given generalized meaning of physics.

3. – Results

The partition in four clusters was chosen as the optimal cluster analytic solution. In table I we report the percentage of students for each cluster. A brief description of response profile and our interpretation then follows

Ideal value is the largest cluster is characterized by a high level of idealization and value: physics is interesting because it intrigues, but also because it is important for the development of society, both from a cultural point of view and for technological applications; it therefore influences the daily life of each of us and it is therefore necessary to know it. Society can trust the progress of physics and the contribution of physicists. This cluster represents a conservative attitude toward physics as taught at school.

For students in the *Blurred discipline* cluster, physics seems to qualify as a discipline among many others, with not too tangible effects on society although it retains residues of personal interest and charm. Such attitude brings to a discouraging view of physicists, regarded as underrated by society. This cluster seems to reflect a latent sense of dissatisfaction with the overall personal experience with physics.

Students in the *Hard and irrelevant* cluster think that physics is difficult to learn, it arises little interest and it is of little importance for society. Even in consideration of future developments and employment opportunities, physics seems to be less attractive than other subjects. Physicists are perceived of little use to society, they are not requested by the job market and hence are poorly paid. Furthermore, their researches often lead to erroneous conclusions. In this cluster, a profoundly negative and widely generalized assessment of physics is observed, including all aspects of interest and motivation, both social and individual. This cluster seems to represent a refusal reaction towards physics.

Finally, the *Practical value* cluster is characterized by a very pragmatic and utilitarian view. Physics is considered in many ways a useful resource, also in daily life. The work of physicists is considered as useful and, even though already appreciated by society, it still deserves higher consideration. Hence, it is believed that physics offers great opportunities of stimulating employments, with high wages. Physics is neither complicated nor abstract; on the contrary, its importance precisely lies in its own applications and in the problems that it can solve. The interest for applications is what most differentiates the

fourth cluster from the first one, which is instead characterized by inclination for theory and fundamental aspects. Students in this cluster not only are satisfied with how they learn physics but also with what they will do with the knowledge they will gain: in this sense, students who identify with this view see themselves as a possible resource for the community development.

4. – Conclusions

There is a long tradition of studies in science education regarding attitudes, values, beliefs about science, and physics in particular [7-10]. This work is an attempt to address this research topic by focusing on the ongoing process of sensemaking when dealing with physics from a socio-cultural psychological perspective. In doing so, we modelled the cultural milieu of physics by means of a semiotic space in which the sensemaking process substantiates in one possible trajectory around different generalized meanings.

In future studies, it is worth investigating the extent to which the generalized representations are actually related to students' choices to enrol in a physics undergraduate course. The present study suggests that students who identify with the "ideal value" and "practical value" are those more likely willing to be engaged in physics-focused activities and hence to pursue and persist in a physics career. Further research can also investigate the extent to which specifically designed school and out-of-school experiences can modify the underpinning dynamics of sensemaking by increasing the self-efficacy, the confidence or the performance in physics. Addressing these issues may have important consequences for refining the interpretative models about students' motivation towards physics and for devising new and innovative ways to impact on the teaching of physics at both secondary and university level.

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