Design and validation of an instrument to measure participation of students in the activities of the National Plan for Scientific Degrees (PLS): The SAAE instrument

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Summary. — In this study, we present a questionnaire aimed at evaluating the involvement of students in the activities of the National Plan for Scientific Degrees (Piano Lauree Scientifiche) through the multidimensional construct of engagement. The questionnaire was presented to about 1000 secondary school students attending Biology, Chemistry and Physics PLS activities at the Federico II University of Naples. The instrument has four dimensions: Satisfaction with the activities followed, Utility of the PLS, Difficulties in following the activities, Involvement of close people. Students were then clustered according to their answers to the questionnaire. Implications of the study for the evaluation of the third mission of the universities are briefly presented.

1. – Introduction and aims

Since 2004, the Piano Nazionale Lauree Scientifiche (PLS) aims at improving secondary students' scientific literacy and also favouring enrolling in scientific degree courses, as Chemistry, Biology, and Physics. However, no studies have yet focused on how to measure students' participation in PLS activities. This article describes the design and development of an instrument called *Science Activities Engagement Evaluation* (SAEE) aimed at measuring students' engagement in PLS activities. In this work, we will define engagement as a multidimensional construct that includes four dimensions [1-5]: *interest*, *perceived utility*, *difficulties encountered*, *inclusion of significant others*. To establish its validity, we will study the correlations between the engagement measured by the SAAE dimensions and motivation. Motivation is considered a factor that has a determining influence on the way students learn, their performance at school and the type of goals

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they set [6]. The Motivation scale that we will use in this study has the following dimensions: *identified motivation, extrinsic motivation, intrinsic motivation, introjected motivation* [7]. The research questions are:

- RQ1: What are the psychometric properties of the SAEE questionnaire?

- RQ2: Is it possible to segment a sample of students who attended the PLS activities according to their engagement?

- RQ3: What is the relationships between students' engagement in PLS activities and contextual variables?

2. – Methods

2˙1. *Sample*. – A convenience sample of 1005 high school students from 30 different schools in a large town in the South of Italy was involved in the study. Overall 923 students returned valid responses. About 30.4% of the students were from grade 9 to 11, 29% from grade 12, 40.5% from grade 13. About 39.3% attended biology activities, 30.1% chemistry activities and 30.6% physics activities.

2˙2. *Instrument and measures*. – The initial version of the SAEE included 41 items. For each item, the students were asked to state their degree of agreement by using a 5-point Likert scale (1 = not at all; 5 = completely). Motivation was measured using 20 items on a 7-point Likert scale divided into four dimensions as described in [7]. Example items are: *I attended PLS activities because it is useful for my future*; *I attended PLS activities because I was interested*. Contextual measure were:

- school grades in Mathematics, Science and Physics.

- intention to enrol into an University degree. Five categories were identified: undecided towards STEM course (17.9%); undecided towards STEM course coherent with attended activities (31.4%); Medicine (22.4%); STEM course not coherent with the attended activities (14.0%); no STEM course (14.3%).

2˙3. *Data analysis*. – To validate the factorial structure of the SAEE (RQ1), we used first an exploratory factor analysis and then a confirmatory factor analysis. The exploratory factor analysis was carried out on a random half of the sample. To extract the factors, we used Principal Axis Factoring and a Promax rotation. To establish how many factors to retain we carried out a parallel analysis. Once the latent factors had been identified, we kept on the item with *loadings* greater than 0.4. The resulting factorial structure was validated though a confirmatory factor analysis on the other half of the sample. To verify the goodness of the fit we calculated χ^2/df (acceptable values ≤ 3), the Root Mean Square Error of Approximation (RMSEA), acceptable values < 0.08), the comparative Fit Index, acceptable values ≥ 0.90) and the Tucker-Lewis Index, acceptable values ≥ 0.90) [8]. To establish the criterion validity we calculated the correlation between the SAAE factors and the motivation dimensions. To answer RQ2, we conducted a cluster analysis using the K-means algorithm. Finally, to answer RQ3, we carried out a series of χ^2 association tests and analysis of variance (ANOVA).

TABLE I. – *Confirmatory factor analysis of the SAEE instrument.*

χ^2	χ^2/df	CFI	TLI	RMSEA
857.8 ($p = 0.00$)	2.494	0.925	0.917	0.058

3. – Results

RQ1. The exploratory factor analysis confirmed the hypothesized four factors structure for the SAEE instrument:

- *Satisfaction towards the activities*: 18 items, Cronbach's alpha 0.95.

- *Utility*: 5 items, Cronbach's alpha 0.84.

- *Difficulty*: 4 items, Cronbach's alpha $= 0.76$.

- *Involvement of others*: 3 items, Cronbach's alpha 0.81.

Explained variance is 35.96%, 7.99%, 4.50%, 3.87%, respectively. The confirmatory factor analysis supports the statistical robustness of the factorial structure of the SAEE (table I).

The Pearson correlations between the four factors of the SAAE instrument and the four motivational dimensions support the criterion validity of the SAEE (table II).

RQ2. Three students' profiles emerged from the cluster analysis:

- The first profile (43.3%) is characterized by high scores in all the SAAE dimensions, except the *difficulty* dimension. Students have therefore perceived PLS activities as a "*Useful and positive experience*".

TABLE II. – *Correlations between SAAE factors and motivation dimensions. E1 = Satisfaction towards the activities, E2 = Utility, E3 = Difficulty, E4 = Involvement of others; M1 = identified; M2 = extrinsic motivation, M3 = intrinsic motivation, M4 = introjected motivation.*

	E1	E2	E3	E4	M1	M2	M3	M4
E1	1							
E2	0.790**	1						
E3	−0.444**	−0.281**	1					
E4	0.646**	0.559**	−0.117*	1				
M1	0.591**	0.816**	−0.238**	0.440**	1			
M2	−0.266**	−0.202**	0.268**	−0.202**	−0.171**	1		
M3	0.696**	0.600**	−0.386**	0.420**	0.627**	−0.317**	1	
M4	0.312**	0.323**	−0.029	0.227**	0.358**	0.152**	0.289**	1

*Correlation is significant at 0.05 level.
**Correlation is significant at 0.01 level.

- The second profile (24.2%) is characterized by low scores in the *utility* dimension and high scores in the *difficulty* and *involvement of the others* dimensions. Therefore, the students in this cluster perceived PLS activities as an "*Experience with frustrated expectations*".

- The third profile (32.5%) is characterized by low scores in all dimensions. Therefore, the students in this cluster perceived PLS activities as a "*Negative experience*".

RQ3. The association between students' profiles and the type of attended PLS activities is significant ($\chi^2 = 27.718$; $df = 4$; $p < 10^{-4}$; V di Cramer $= 0.12$). In particular, students who attended biology activities were the most engaged, while students who attended physics PLS perceived greater difficulties in participating in the activities. Students who attended chemistry PLS were the most disappointed. The association between students' profiles and the school year is also significant $\chi^2 = 11.861$; $df = 4$; $p = 0.02$; V di Cramer $= 0.080$. In particular, about half of the 9–11 grade students considered activities as engaging, while more than half of the 13 grade students found PLS activities as *negative* or *disappointing*. As expected, engagement in PLS activities is not related to the students' future university choices $\chi^2 = 10.458$; $df = 8$; $p = 0.234$; V di Cramer $= 0.075$ and to school grades, except for the *Sciences* subject ($F = 5.869$, $df = 2, 915$; $p < 0.01$). In particular, more engaged students (first profile) reported significantly higher school grades in this subject.

4. – Conclusions

The main aim of this study was to validate a new instrument (called SAAE) to evaluate students' engagement in PLS activities. The final version features 30 items and shows a robust factor structure, a good criterion validity and reliability. The main implication of our study is the possibility of using the SAAE questionnaire to evaluate PLS activities at a national level. In a scenario where universities will be increasingly evaluated on third-mission initiatives, equipping the PLS consortium with a quantitative tool to collect evidence on their effectiveness seems to be a goal that can be pursued with the utmost determination. The final version of the SAAE instrument is available by request to the corresponding author.

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