Summary report of CHAEA learning styles by CHAEA³S package

This report contains the most important results of the analysis that is conducted to unveil the learning styles that are present in the group of students under study. The analysis is based on the learning styles considered by CHAEA: active, reflector, theorists, and pragmatist. Unless otherwise stated, the uncertainties throughout the document (in parenthesis) have been obtained using a t-Student distribution with a confidence interval of 95%.

The report is structured as follows. First, Section 1 is devoted to the individual and global statistical analysis. Here, the importance of the different learning styles for each individual student can be found (both quantitatively as well as qualitatively). Then, average means and confidence intervals are presented, along with the affinities and the Probability Density Functions. Second, Section 2 discusses the principal component analysis. The eigenvalues and eigenvectors of the covariance matrix are first introduced. Subsequently, the learning styles of the students in the principal components basis set is presented. Finally, a reduced dimensional representation of the data is conducted. Third, the participation ratios are finally presented in Section 3. The values for the original (active, theorist, pragmatic, and reflector) and in the principal components basis sets are listed. To conclude, a statistical analysis of the distribution of the participation ratios is performed.

Further information at: J. Ablanque, V. Gabaldon, P. Almendros, J. C. Losada, R. M. Benito, and F. Revuelta. CHAEA3S: A software for the automated principal-component analysis of learning styles. Journal of Science Education and Technology (2024).

1. Individual and global statistical analysis

In this section we present the individual and global statistical analysis of the learning styles as originally defined in CHAEA (activist, reflector, theorist, and pragmatist). This section is divided in two parts. First, the (quantitative and qualitative) importance of the different learning styles for each individual student can be found. Second, a global analysis is performed, where average means, confidence intervals, affinities, and the probability density functions can be found.

1.1 Individual analysis

Quantitative description of the learning styles for each individual student

Table 1 shows the number of points (from 0 to 20) that each student gets in CHAEA for the different learning styles.

Table 1. Points related the learning styles for each of the students.

Student	Activist	Reflector	Theorist	Pragmatist
fisicaI_2022-23_01.xls	14.0	14.0	14.0	15.0
fisicaI_2022-23_02.xls	13.0	18.0	12.0	10.0
fisicaI_2022-23_03.xls	13.0	15.0	14.0	13.0
fisicaI_2022-23_04.xlsx	9.0	17.0	13.0	8.0
fisicaI_2022-23_05.xlsx	15.0	18.0	12.0	13.0
fisicaI_2022-23_06.xls	17.0	13.0	16.0	12.0
fisicaI_2022-23_07.xlsx	14.0	17.0	11.0	11.0
fisicaI_2022-23_08.xls	8.0	18.0	20.0	15.0

fisicaI_2022-23_09.xls	6.0	15.0	15.0	12.0
fisicaI_2022-23_11.xls	14.0	16.0	12.0	14.0
fisicaI_2022-23_12.xls	17.0	15.0	19.0	18.0
fisicaI_2022-23_13.xlsx	17.0	15.0	13.0	17.0
fisicaI_2022-23_14.xls	6.0	17.0	8.0	9.0
fisicaI_2022-23_15.xlsx	10.0	13.0	11.0	10.0
fisicaI_2022-23_17.xls	9.0	16.0	12.0	13.0
fisicaI_2022-23_18.xls	9.0	19.0	14.0	13.0
fisicaI_2022-23_19.xls	10.0	16.0	15.0	16.0
fisicaI_2022-23_20.xls	10.0	12.0	13.0	13.0
fisicaI_2022-23_21.xls	15.0	16.0	11.0	15.0
fisicaI_2022-23_22.xlsx	15.0	13.0	11.0	19.0
fisicaI_2022-23_23.xls	11.0	18.0	17.0	12.0
fisicaI_2022-23_24.xls	10.0	12.0	13.0	16.0
fisicaI_2022-23_25.xls	12.0	15.0	13.0	10.0
fisicaI_2022-23_26.xls	13.0	16.0	11.0	11.0
fisicaI_2022-	13.0	19.0	15.0	14.0

23_27.xls				
fisicaI_2022-23_30.xls	9.0	16.0	12.0	14.0
fisicaI_2022-23_31.xls	15.0	19.0	9.0	15.0
fisicaI_2022-23_33.xlsx	10.0	9.0	11.0	14.0
fisicaI_2022-23_34.xls	15.0	10.0	13.0	20.0
fisicaI_2022-23_35.xls	16.0	18.0	8.0	9.0
fisicaI_2022-23_36.xls	10.0	15.0	11.0	14.0
fisicaI_2022-23_37.xls	8.0	15.0	12.0	13.0
fisicaI_2022-23_38.xlsx	10.0	15.0	8.0	7.0
fisicaI_2022-23_39.xls	4.0	20.0	18.0	13.0
fisicaI_2022-23_40.xls	9.0	19.0	11.0	19.0
fisicaI_2022-23_41.xls	11.0	15.0	16.0	16.0
fisicaI_2022-23_42.xls	11.0	17.0	15.0	12.0
fisicaI_2022-23_43.xls	9.0	16.0	14.0	13.0
fisicaI_2022-23_44.xls	12.0	15.0	13.0	14.0
fisicaI_2022-23_45.xlsx	14.0	13.0	15.0	12.0

fisicaI_2022-23_46.xls	8.0	18.0	12.0	12.0
fisicaI_2022-23_47.xls	11.0	15.0	10.0	10.0
fisicaI_2022-23_48.xls	8.0	19.0	19.0	15.0
fisicaI_2022-23_49.xls	12.0	16.0	13.0	12.0
fisicaI_2022-23_50.xls	5.0	19.0	17.0	11.0
fisicaI_2022-23_51.xls	2.0	16.0	14.0	7.0
fisicaI_2022-23_52.xls	6.0	16.0	13.0	11.0
fisicaI_2022-23_53.xlsx	12.0	18.0	14.0	17.0
fisicaI_2022-23_54.xlsx	11.0	17.0	15.0	12.0
fisicaI_2022-23_55.xls	12.0	16.0	15.0	10.0
fisicaI_2022-23_56.xls	11.0	18.0	10.0	12.0
fisicaI_2022-23_57.xls	13.0	12.0	13.0	14.0
fisicaI_2022-23_58.xlsx	12.0	17.0	16.0	12.0
fisicaI_2022-23_59.xls	5.0	15.0	13.0	8.0
fisicaI_2022-23_61.xls	12.0	12.0	10.0	12.0
fisicaI_2022-23_62.xls	7.0	14.0	14.0	12.0
fisicaI_2022-	10.0	16.0	14.0	11.0

23_63.xlsx				
fisicaI_2022-23_64.xlsx	7.0	13.0	8.0	8.0
fisicaI_2022-23_65.xls	9.0	13.0	16.0	14.0
fisicaI_2022-23_66.xls	6.0	15.0	9.0	7.0
fisicaI_2022-23_67.xls	12.0	14.0	11.0	15.0
fisicaI_2022-23_68.xls	13.0	15.0	11.0	9.0
fisicaI_2022-23_69.xls	15.0	14.0	12.0	12.0
fisicaI_2022-23_70.xls	13.0	13.0	6.0	7.0
fisicaI_2022-23_71.xls	0.0	0.0	0.0	0.0
fisicaI_2022-23_72.xls	13.0	17.0	16.0	12.0
fisicaI_2022-23_73.xls	12.0	17.0	14.0	14.0
fisicaI_2022-23_74.xlsx	6.0	15.0	15.0	7.0
fisicaI_2022-23_75.xls	12.0	12.0	14.0	10.0
fisicaI_2022-23_76.xls	14.0	10.0	7.0	10.0
fisicaI_2023-24_01.xls	13.0	16.0	10.0	13.0
fisicaI_2023-24_02.xls	10.0	17.0	18.0	19.0

fisicaI_2023-24_03.xlsx	14.0	17.0	18.0	15.0
fisicaI_2023-24_04.xls	17.0	16.0	12.0	13.0
fisicaI_2023-24_05.xls	17.0	11.0	9.0	9.0
fisicaI_2023-24_06.xlsx	9.0	20.0	17.0	14.0
fisicaI_2023-24_07.xlsx	8.0	18.0	17.0	14.0
fisicaI_2023-24_08.xls	15.0	11.0	9.0	14.0
fisicaI_2023-24_09.xls	13.0	15.0	14.0	16.0
fisicaI_2023-24_10.xls	9.0	17.0	13.0	13.0
fisicaI_2023-24_11.xlsx	7.0	16.0	15.0	11.0
fisicaI_2023-24_12.xls	9.0	13.0	16.0	14.0
fisicaI_2023-24_13.xls	10.0	18.0	12.0	8.0
fisicaI_2023-24_14.xls	11.0	15.0	13.0	12.0
fisicaI_2023-24_15.xls	11.0	20.0	15.0	10.0
fisicaI_2023-24_16.xls	8.0	19.0	15.0	13.0
fisicaI_2023-24_17.xls	12.0	17.0	15.0	10.0
fisicaI_2023-24_18.xls	9.0	16.0	16.0	18.0
fisicaI_2023-	3.0	17.0	18.0	12.0

24_20.xls				
fisicaI_2023-24_21.xls	7.0	17.0	15.0	11.0
fisicaI_2023-24_22.xls	10.0	9.0	15.0	9.0
fisicaI_2023-24_23.xls	9.0	15.0	14.0	11.0
fisicaI_2023-24_24.xls	14.0	13.0	8.0	15.0
fisicaI_2023-24_25.xls	16.0	11.0	15.0	15.0
fisicaI_2023-24_26.xls	8.0	18.0	17.0	10.0
fisicaI_2023-24_27.xls	15.0	18.0	18.0	18.0
fisicaI_2023-24_28.xls	6.0	20.0	17.0	13.0
fisicaI_2023-24_29.xlsx	6.0	1.0	3.0	6.0
fisicaI_2023-24_30.xls	14.0	17.0	15.0	13.0
fisicaI_2023-24_31.xls	17.0	17.0	15.0	20.0
fisicaI_2023-24_32.xls	12.0	11.0	18.0	11.0
fisicaI_2023-24_33.xls	15.0	17.0	13.0	13.0
fisicaI_2023-24_34.xls	16.0	13.0	14.0	18.0
fisicaI_2023-24_35.xls	11.0	19.0	12.0	12.0

fisicaI_2023-24_36.xls	12.0	16.0	15.0	16.0
fisicaI_2023-24_37.xls	14.0	13.0	7.0	11.0
fisicaI_2023-24_38.xlsx	6.0	17.0	16.0	15.0
fisicaI_2023-24_39.xlsx	15.0	19.0	14.0	14.0
fisicaI_2023-24_40.xls	10.0	18.0	14.0	13.0
fisicaI_2023-24_41.xls	2.0	17.0	13.0	12.0
fisicaI_2023-24_42.xls	15.0	12.0	10.0	13.0
fisicaI_2023-24_43.xls	9.0	19.0	15.0	11.0
fisicaI_2023-24_44.xlsx	3.0	17.0	15.0	9.0
fisicaI_2023-24_45.xls	8.0	18.0	16.0	17.0
fisicaI_2023-24_46.xls	5.0	20.0	14.0	11.0
fisicaI_2023-24_47.xls	10.0	13.0	15.0	14.0
fisicaI_2023-24_48.xls	16.0	13.0	11.0	16.0
fisicaI_2023-24_49.xlsx	9.0	15.0	12.0	14.0
fisicaI_2023-24_50.xlsx	5.0	17.0	16.0	12.0
fisicaI_2023-24_51.xls	13.0	17.0	10.0	12.0
fisicaI_2023-	11.0	15.0	15.0	14.0

24_52.xlsx				
fisicaI_2023-24_53.xlsx	11.0	18.0	16.0	14.0
fisicaI_2023-24_54.xlsx	11.0	15.0	14.0	13.0
fisicaI_2023-24_55.xls	13.0	12.0	16.0	17.0
fisicaI_2023-24_56.xls	12.0	13.0	15.0	10.0
fisicaI_2023-24_57.xlsx	11.0	15.0	16.0	13.0
fisicaI_2023-24_58.xls	9.0	19.0	18.0	16.0
fisicaI_2023-24_59.xls	14.0	18.0	16.0	16.0
fisicaI_2023-24_60.xlsx	14.0	18.0	18.0	18.0

Qualitative description of the learning styles for each individual student

Table 2 shows the individual qualitative tendency (very low, low, moderate, high, or very high) that each student has towards each of the learning styles.

Table 2. Tendency towards the learning styles for each of the students.

Student	Activist	Reflector	Theorist	Pragmatist
fisicaI_2022-23_01.xls	High	Moderate	High	High
fisicaI_2022-23_02.xls	High	High	Moderate	Low
fisicaI_2022-23_03.xls	High	Moderate	High	Moderate
fisicaI_2022-23_04.xlsx	Moderate	Moderate	Moderate	Very low
fisicaI_2022-23_05.xlsx	Very high	High	Moderate	Moderate
fisicaI_2022-23_06.xls	Very high	Low	Very high	Moderate
fisicaI_2022-23_07.xlsx	High	Moderate	Moderate	Moderate
fisicaI_2022-23_08.xls	Low	High	Very high	High
fisicaI_2022-23_09.xls	Very low	Moderate	High	Moderate
fisicaI_2022-23_11.xls	High	Moderate	Moderate	High
fisicaI_2022-23_12.xls	Very high	Moderate	Very high	Very high
fisicaI_2022-23_13.xlsx	Very high	Moderate	Moderate	Very high

fisicaI_2022-23_14.xls	Very low	Moderate	Low	Low
fisicaI_2022-23_15.xlsx	Moderate	Low	Moderate	Low
fisicaI_2022-23_17.xls	Moderate	Moderate	Moderate	Moderate
fisicaI_2022-23_18.xls	Moderate	High	High	Moderate
fisicaI_2022-23_19.xls	Moderate	Moderate	High	Very high
fisicaI_2022-23_20.xls	Moderate	Low	Moderate	Moderate
fisicaI_2022-23_21.xls	Very high	Moderate	Moderate	High
fisicaI_2022-23_22.xlsx	Very high	Low	Moderate	Very high
fisicaI_2022-23_23.xls	Moderate	High	Very high	Moderate
fisicaI_2022-23_24.xls	Moderate	Low	Moderate	Very high
fisicaI_2022-23_25.xls	Moderate	Moderate	Moderate	Low
fisicaI_2022-23_26.xls	High	Moderate	Moderate	Moderate
fisicaI_2022-23_27.xls	High	High	High	High
fisicaI_2022-23_30.xls	Moderate	Moderate	Moderate	High
fisicaI_2022-23_31.xls	Very high	High	Low	High
fisicaI_2022-23_33.xlsx	Moderate	Very low	Moderate	High
fisicaI_2022-	Very high	Very low	Moderate	Very high

23_34.xls				
fisicaI_2022-23_35.xls	Very high	High	Low	Low
fisicaI_2022-23_36.xls	Moderate	Moderate	Moderate	High
fisicaI_2022-23_37.xls	Low	Moderate	Moderate	Moderate
fisicaI_2022-23_38.xlsx	Moderate	Moderate	Low	Very low
fisicaI_2022-23_39.xls	Very low	Very high	Very high	Moderate
fisicaI_2022-23_40.xls	Moderate	High	Moderate	Very high
fisicaI_2022-23_41.xls	Moderate	Moderate	Very high	Very high
fisicaI_2022-23_42.xls	Moderate	Moderate	High	Moderate
fisicaI_2022-23_43.xls	Moderate	Moderate	High	Moderate
fisicaI_2022-23_44.xls	Moderate	Moderate	Moderate	High
fisicaI_2022-23_45.xlsx	High	Low	High	Moderate
fisicaI_2022-23_46.xls	Low	High	Moderate	Moderate
fisicaI_2022-23_47.xls	Moderate	Moderate	Moderate	Low
fisicaI_2022-23_48.xls	Low	High	Very high	High
fisicaI_2022-23_49.xls	Moderate	Moderate	Moderate	Moderate

fisicaI_2022-23_50.xls	Very low	High	Very high	Moderate
fisicaI_2022-23_51.xls	Very low	Moderate	High	Very low
fisicaI_2022-23_52.xls	Very low	Moderate	Moderate	Moderate
fisicaI_2022-23_53.xlsx	Moderate	High	High	Very high
fisicaI_2022-23_54.xlsx	Moderate	Moderate	High	Moderate
fisicaI_2022-23_55.xls	Moderate	Moderate	High	Low
fisicaI_2022-23_56.xls	Moderate	High	Moderate	Moderate
fisicaI_2022-23_57.xls	High	Low	Moderate	High
fisicaI_2022-23_58.xlsx	Moderate	Moderate	Very high	Moderate
fisicaI_2022-23_59.xls	Very low	Moderate	Moderate	Very low
fisicaI_2022-23_61.xls	Moderate	Low	Moderate	Moderate
fisicaI_2022-23_62.xls	Low	Moderate	High	Moderate
fisicaI_2022-23_63.xlsx	Moderate	Moderate	High	Moderate
fisicaI_2022-23_64.xlsx	Low	Low	Low	Very low
fisicaI_2022-23_65.xls	Moderate	Low	Very high	High
fisicaI_2022-23_66.xls	Very low	Moderate	Low	Very low
fisicaI_2022-	Moderate	Moderate	Moderate	High

23_67.xls				
fisicaI_2022-23_68.xls	High	Moderate	Moderate	Low
fisicaI_2022-23_69.xls	Very high	Moderate	Moderate	Moderate
fisicaI_2022-23_70.xls	High	Low	Very low	Very low
fisicaI_2022-23_71.xls	Very low	Very low	Very low	Very low
fisicaI_2022-23_72.xls	High	Moderate	Very high	Moderate
fisicaI_2022-23_73.xls	Moderate	Moderate	High	High
fisicaI_2022-23_74.xlsx	Very low	Moderate	High	Very low
fisicaI_2022-23_75.xls	Moderate	Low	High	Low
fisicaI_2022-23_76.xls	High	Very low	Low	Low
fisicaI_2023-24_01.xls	High	Moderate	Moderate	Moderate
fisicaI_2023-24_02.xls	Moderate	Moderate	Very high	Very high
fisicaI_2023-24_03.xlsx	High	Moderate	Very high	High
fisicaI_2023-24_04.xls	Very high	Moderate	Moderate	Moderate
fisicaI_2023-24_05.xls	Very high	Low	Low	Low
fisicaI_2023-24_06.xlsx	Moderate	Very high	Very high	High

fisicaI_2023-24_07.xlsx	Low	High	Very high	High
fisicaI_2023-24_08.xls	Very high	Low	Low	High
fisicaI_2023-24_09.xls	High	Moderate	High	Very high
fisicaI_2023-24_10.xls	Moderate	Moderate	Moderate	Moderate
fisicaI_2023-24_11.xlsx	Low	Moderate	High	Moderate
fisicaI_2023-24_12.xls	Moderate	Low	Very high	High
fisicaI_2023-24_13.xls	Moderate	High	Moderate	Very low
fisicaI_2023-24_14.xls	Moderate	Moderate	Moderate	Moderate
fisicaI_2023-24_15.xls	Moderate	Very high	High	Low
fisicaI_2023-24_16.xls	Low	High	High	Moderate
fisicaI_2023-24_17.xls	Moderate	Moderate	High	Low
fisicaI_2023-24_18.xls	Moderate	Moderate	Very high	Very high
fisicaI_2023-24_20.xls	Very low	Moderate	Very high	Moderate
fisicaI_2023-24_21.xls	Low	Moderate	High	Moderate
fisicaI_2023-24_22.xls	Moderate	Very low	High	Low
fisicaI_2023-24_23.xls	Moderate	Moderate	High	Moderate
fisicaI_2023-	High	Low	Low	High

24_24.xls				
fisicaI_2023-24_25.xls	Very high	Low	High	High
fisicaI_2023-24_26.xls	Low	High	Very high	Low
fisicaI_2023-24_27.xls	Very high	High	Very high	Very high
fisicaI_2023-24_28.xls	Very low	Very high	Very high	Moderate
fisicaI_2023-24_29.xlsx	Very low	Very low	Very low	Very low
fisicaI_2023-24_30.xls	High	Moderate	High	Moderate
fisicaI_2023-24_31.xls	Very high	Moderate	High	Very high
fisicaI_2023-24_32.xls	Moderate	Low	Very high	Moderate
fisicaI_2023-24_33.xls	Very high	Moderate	Moderate	Moderate
fisicaI_2023-24_34.xls	Very high	Low	High	Very high
fisicaI_2023-24_35.xls	Moderate	High	Moderate	Moderate
fisicaI_2023-24_36.xls	Moderate	Moderate	High	Very high
fisicaI_2023-24_37.xls	High	Low	Low	Moderate
fisicaI_2023-24_38.xlsx	Very low	Moderate	Very high	High
fisicaI_2023-24_39.xlsx	Very high	High	High	High

fisicaI_2023-24_40.xls	Moderate	High	High	Moderate
fisicaI_2023-24_41.xls	Very low	Moderate	Moderate	Moderate
fisicaI_2023-24_42.xls	Very high	Low	Moderate	Moderate
fisicaI_2023-24_43.xls	Moderate	High	High	Moderate
fisicaI_2023-24_44.xlsx	Very low	Moderate	High	Low
fisicaI_2023-24_45.xls	Low	High	Very high	Very high
fisicaI_2023-24_46.xls	Very low	Very high	High	Moderate
fisicaI_2023-24_47.xls	Moderate	Low	High	High
fisicaI_2023-24_48.xls	Very high	Low	Moderate	Very high
fisicaI_2023-24_49.xlsx	Moderate	Moderate	Moderate	High
fisicaI_2023-24_50.xlsx	Very low	Moderate	Very high	Moderate
fisicaI_2023-24_51.xls	High	Moderate	Moderate	Moderate
fisicaI_2023-24_52.xlsx	Moderate	Moderate	High	High
fisicaI_2023-24_53.xlsx	Moderate	High	Very high	High
fisicaI_2023-24_54.xlsx	Moderate	Moderate	High	Moderate
fisicaI_2023-24_55.xls	High	Low	Very high	Very high
fisicaI_2023-	Moderate	Low	High	Low

24_56.xls				
fisicaI_2023-24_57.xlsx	Moderate	Moderate	Very high	Moderate
fisicaI_2023-24_58.xls	Moderate	High	Very high	Very high
fisicaI_2023-24_59.xls	High	High	Very high	Very high
fisicaI_2023-24_60.xlsx	High	High	Very high	Very high

1.2 Global analysis

Global tendencies towards the learning styles of the students (I)

Table 3 presents the number and percentage of students with the same tendency (very low, low, moderate, high, or very high) towards each of the learning styles. The bottom line shows the average tendency. These results are also shown as a barr graphic in Fig. 1.

Table 3. Number and percentage of students with the same tendency towards each of the learning styles.

Tendency	Very low		Low		Moderate		High		Very high	
	No.	%	No.	%	No.	%	No.	%	No.	%
Activist	18	14.0	12	9.3	55	42.6	23	17.8	21	16.3
Reflector	6	4.7	25	19.4	65	50.4	28	21.7	5	3.9
Theorist	3	2.3	11	8.5	44	34.1	40	31.0	31	24.0
Pragmatist	11	8.5	17	13.2	51	39.5	28	21.7	22	17.1
Average mean	38	10.0	65	14.1	215	42.5	119	24.1	79	18.8

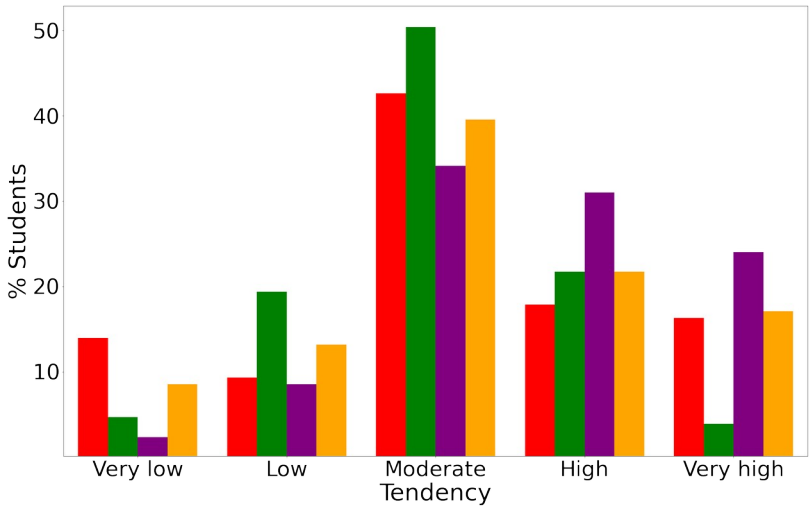

Figure 1. Bar graphic showing the percentage of students with a very low (leftmost), low (left), moderate (middle), high (right) and very high (rightmost) tendency towards the active (red), reflector (green), theorist (purple) and pragmatist (orange) learning styles. The shown results correspond to the values of Table 3.

Global tendencies towards the learning styles of the students (II)

Table 4 shows the average mean and the uncertainties for the different learning styles, along with the corresponding qualitative tendency, and the corresponding affinity. For the shake of clarity, the average profile of the students given by the average means and the corresponding uncertainties is shown in Fig. 2, while the affinities are represented as a barr graphic in Fig. 3.

Table 4. Numerical average values of each learning style with the uncertainties (in parenthesis) along with their qualitative tendency, and the corresponding affinity.

Learning style	Average mean (Uncertainty)	Tendency	Affinity (%)
Activist	10.8(0.6)	Moderate	76.7
Reflector	15.5(0.5)	Moderate	76.0
Theorist	13.4(0.5)	Moderate/ High	89.1
Pragmatist	12.7(0.5)	Moderate	78.3

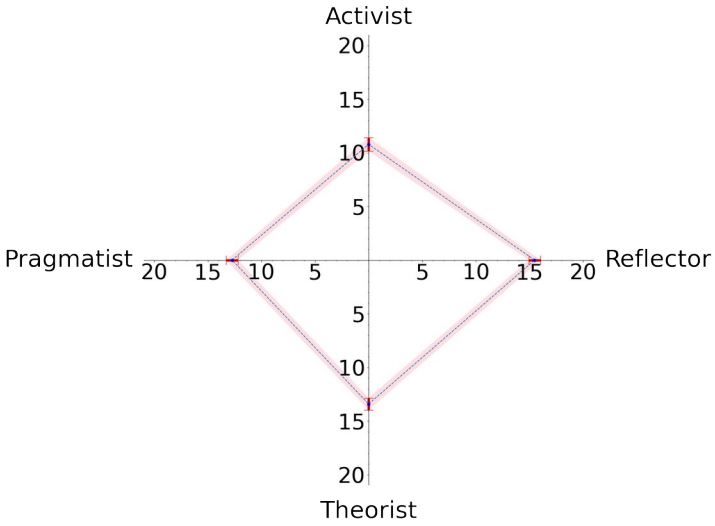

Figure 2. Average profile of the learning styles of the students.

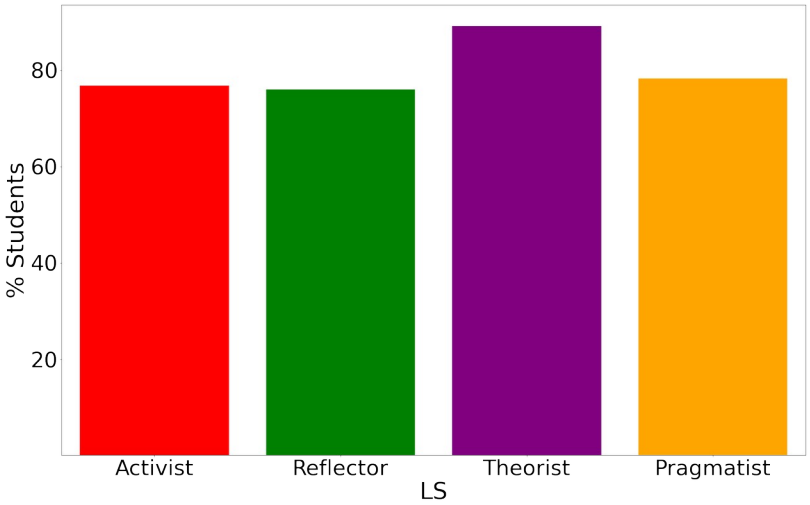

Figure 3. Affinity of the learning styles. The bar graphic gives the percentage of students that have a noticeable tendency towards the active (red), reflector (green), theorist (purple) and pragmatist (orange) learning styles.

Figure 4 shows histograms with the probability distributions of the results of Table 1. The continuous lines show fittings with Weibull distributions with the parameters shown in Table 5. These fittings have been performed on the corresponding cumulative distributions given by the staircases shown in Figure 5.

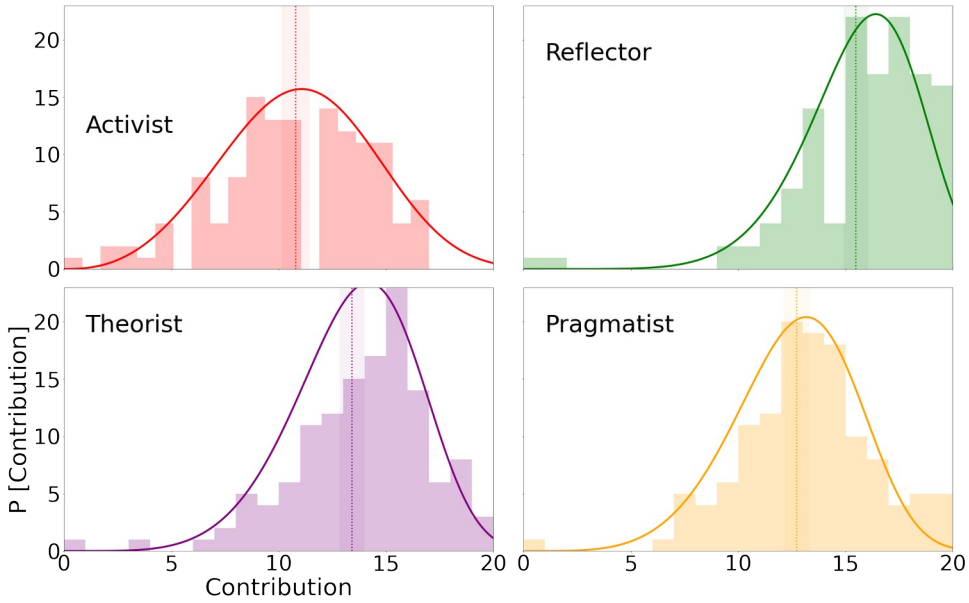

Figure 4. Histograms showing the probability distributions for the activist (red), reflector (green), theorist (purple), and pragmatist (yellow) learning styles. The continuous lines show fittings provided by the Weibull distributions with the parameters contained in Table 5. The vertical dotted lines mark the average values, and the shaded areas around them the corresponding confidence intervals.

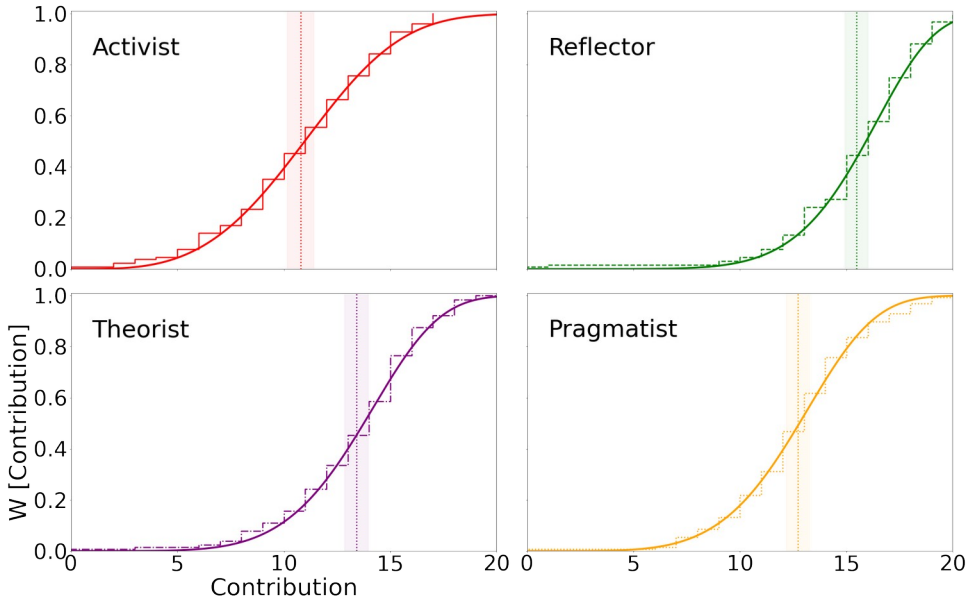

Figure 5. Same as Fig. 4 for the cumulative distributions (staircases).

Table 5. Parameters of the Weibull distributions that fit the probability distributions (histograms) shown in Figs. 4 and 5. The location parameter is set equal to θ = 0.

Learning style	α	k
Activist	12.2	3.48
Reflector	16.78	6.97
Theorist	14.7	5.48
Pragmatist	13.74	5.12

2. Principal component analysis

This section presents the principal component analysis of the learning styles. It is organized as follows. First, the eigenvalues and eigenvectors of the covariance matrix are presented. Second, the description of the learning styles of the students in the principal components basis set is discussed. Finally, a reduced dimensional representation of the data is conducted.

2.1 Structure of the principal components

Eigenvalues and dispersion of the covariance matrix

In this section, we discuss the essentials of the principal components. For this purpose, Table 6 shows the four eigenvalues of the covariance matrix. Here, not only their values are listed but also their contribution to the total dispersion (given by the trace of the covariance matrix tr(K)=43.09, which equals the sum of all the eigenvalues) as a percentage. Likewise, the dispersion accounted by solely the principal component with the largest eigenvalue $\Sigma\_0(\%)=\lambda\_0*100/tr(K)$, and by combining the principal components with the two, three, and four largest eigenvalues $\Sigma\_1(\%)=(\lambda\_0+\lambda\_1)*100/tr(K)$, $\Sigma\_2(\%)=(\lambda\_0+\lambda\_1+\lambda\_2)*100/tr(K)$, and by four $\Sigma\_3(\%)=(\lambda\_0+\lambda\_1+\lambda\_2+\lambda\_3)*100/tr(K)=100\%$, respectively, are given.

Table 6. Eigenvalues of the covariance matrix given by their corresponding values λ_i and as a percentage of the total dispersion, and percentage of total dispersion Σ_i accounted by combination of the principal components with the eigenvalues λ_j, being $j \leq i$.

Principal component (i)	λ_i	$\lambda\_i(\%)$	$\Sigma\_i(\%)$
0	19.08	44.3	44.3
1	14.93	34.6	78.9
2	5.64	13.1	92.0
3	3.44	8.0	100.0

Eigenvectors of the covariance matrix

Table 7 shows the structure of the eigenvectors of the covariance matrix in the basis set of CHAEA learning styles. Each cell contains the percentage of the eigenvector of the principal component 0, 1, 2, and 3 that is projected on the corresponding learning style (activist, reflector, theorist, and pragmatist).

Table 7. Structure (as percentages) of the eigenvectors of the covariance matrix in the basis set of CHAEA learning styles.

Principal component	Activist	Reflector	Theorist	Pragmatist
0	11.7	64.8	11.3	12.1
1	21.0	16.3	56.7	6.0
2	31.6	14.6	11.2	42.6
3	35.6	4.3	20.8	39.2

2.2 Individual analysis of the principal components

Quantitive description of the students in the basis set of the principal components

Table 8 shows (as percentages) the structure of the learning styles in the basis set formed by the principal components. The table also includes the percentage of the learning styles of each student that is described by combining the two (sum of the percentages for the principal components 0 and 1) or three (sum of the percentages for the principal components 0, 1, and 2) principal components with the largest eigenvalues. Recall that when the four principal components are considered, 100% of the learning style of the student is reproduced.

Table 8. Structure of the learning styles of each of the students in the basis set of principal components.

Student	0	1	2	3	0+1	0+1+2
fisicaI_2022-23_01.xls	24.84	65.25	8.84	1.07	90.09	98.93
fisicaI_2022-23_02.xls	1.21	2.64	91.92	4.23	3.85	95.77
fisicaI_2022-23_03.xls	19.44	58.8	0.08	21.68	78.24	78.32
fisicaI_2022-23_04.xlsx	31.32	29.57	28.86	10.25	60.89	89.75
fisicaI_2022-23_05.xlsx	14.87	33.68	51.21	0.23	48.56	99.77
fisicaI_2022-23_06.xl	7.85	45.51	0.18	46.46	53.36	53.54

s						
fisicaI_2022-23_07.xlsx	1.58	30.01	68.12	0.29	31.59	99.71
fisicaI_2022-23_08.xls	44.29	44.82	8.26	2.63	89.12	97.37
fisicaI_2022-23_09.xls	7.4	74.62	17.96	0.01	82.02	99.99
fisicaI_2022-23_11.xls	12.1	71.05	13.11	3.74	83.15	96.26
fisicaI_2022-23_12.xls	68.72	17.65	6.6	7.03	86.37	92.97
fisicaI_2022-23_13.xlsx	31.27	67.94	0.01	0.77	99.22	99.23
fisicaI_2022-23_14.xls	56.28	14.74	13.59	15.39	71.02	84.61
fisicaI_2022-23_15.xlsx	96.27	2.62	0.03	1.08	98.89	98.92
fisicaI_2022-23_17.xls	17.93	20.0	0.36	61.7	37.94	38.3

fisicaI_2022-23_18.xls	14.11	57.04	18.69	10.16	71.15	89.84
fisicaI_2022-23_19.xls	56.32	4.17	25.31	14.2	60.49	85.8
fisicaI_2022-23_20.xls	28.67	7.51	63.67	0.14	36.18	99.86
fisicaI_2022-23_21.xls	9.83	72.07	8.61	9.49	81.9	90.51
fisicaI_2022-23_22.xlsx	10.57	63.36	9.05	17.02	73.92	82.98
fisicaI_2022-23_23.xls	40.11	28.2	6.15	25.53	68.32	74.47
fisicaI_2022-23_24.xls	0.08	10.97	76.08	12.88	11.04	87.12
fisicaI_2022-23_25.xls	29.55	6.26	22.1	42.09	35.81	57.91
fisicaI_2022-23_26.xls	13.68	32.65	53.51	0.16	46.34	99.84
fisicaI_2022-	75.6	0.0	24.3	0.1	75.6	99.9

23_27.xls						
fisicaI_2022-23_30.xls	2.24	10.04	1.4	86.32	12.28	13.68
fisicaI_2022-23_31.xls	6.87	31.1	37.06	24.98	37.97	75.02
fisicaI_2022-23_33.xlsx	29.33	20.08	48.35	2.25	49.4	97.75
fisicaI_2022-23_34.xls	9.21	52.42	34.34	4.03	61.64	95.97
fisicaI_2022-23_35.xls	7.01	26.1	66.89	0.0	33.11	100.0
fisicaI_2022-23_36.xls	14.0	6.73	1.9	77.37	20.73	22.63
fisicaI_2022-23_37.xls	32.15	21.04	8.95	37.87	53.18	62.13
fisicaI_2022-23_38.xlsx	76.7	0.31	22.97	0.02	77.01	99.98
fisicaI_2022-23_39.xl	7.14	92.05	0.33	0.49	99.19	99.51

s						
fisicaI_2022-23_40.xls	18.99	0.66	0.0	80.35	19.65	19.65
fisicaI_2022-23_41.xls	60.36	0.02	39.46	0.17	60.38	99.83
fisicaI_2022-23_42.xls	28.24	26.46	19.2	26.11	54.7	73.89
fisicaI_2022-23_43.xls	0.43	84.88	7.16	7.53	85.31	92.47
fisicaI_2022-23_44.xls	15.28	72.34	4.4	7.98	87.62	92.02
fisicaI_2022-23_45.xlsx	0.95	41.07	4.95	53.03	42.02	46.97
fisicaI_2022-23_46.xls	6.22	49.53	18.77	25.48	55.75	74.52
fisicaI_2022-23_47.xls	70.32	6.3	22.81	0.57	76.62	99.43
fisicaI_2022-23_48.xls	47.17	50.07	2.5	0.26	97.24	99.74

fisicaI_2022-23_49.xls	0.0	24.5	66.16	9.34	24.5	90.66
fisicaI_2022-23_50.xls	0.64	98.75	0.14	0.47	99.38	99.53
fisicaI_2022-23_51.xls	30.96	68.47	0.02	0.55	99.43	99.45
fisicaI_2022-23_52.xls	26.8	69.18	0.32	3.7	95.98	96.3
fisicaI_2022-23_53.xlsx	75.03	1.47	0.1	23.4	76.5	76.6
fisicaI_2022-23_54.xlsx	28.24	26.46	19.2	26.11	54.7	73.89
fisicaI_2022-23_55.xls	0.04	1.4	19.67	78.88	1.45	21.12
fisicaI_2022-23_56.xls	6.69	0.51	63.86	28.94	7.21	71.06
fisicaI_2022-23_57.xls	0.48	69.33	28.55	1.64	69.81	98.36
fisicaI_2022-	41.58	5.44	9.47	43.51	47.02	56.49

23_58.xlsx						
fisicaI_2022-23_59.xls	49.04	49.85	0.0	1.11	98.89	98.89
fisicaI_2022-23_61.xls	48.33	48.59	2.11	0.97	96.92	99.03
fisicaI_2022-23_62.xls	24.69	46.06	29.17	0.08	70.75	99.92
fisicaI_2022-23_63.xlsx	12.43	48.4	12.4	26.77	60.83	73.23
fisicaI_2022-23_64.xlsx	95.46	1.29	0.95	2.3	96.75	97.7
fisicaI_2022-23_65.xls	1.28	7.65	86.74	4.33	8.93	95.67
fisicaI_2022-23_66.xls	79.78	13.3	5.97	0.95	93.08	99.05
fisicaI_2022-23_67.xls	0.44	60.12	5.94	33.5	60.56	66.5
fisicaI_2022-23_68.xl	37.15	18.18	33.76	10.92	55.33	89.08

s						
fisicaI_2022-23_69.xls	0.92	85.34	5.48	8.25	86.27	91.75
fisicaI_2022-23_70.xls	64.17	19.83	15.98	0.02	84.0	99.98
fisicaI_2022-23_71.xls	96.35	0.0	3.57	0.08	96.35	99.92
fisicaI_2022-23_72.xls	42.66	0.01	12.76	44.58	42.67	55.42
fisicaI_2022-23_73.xls	84.39	2.83	10.46	2.32	87.21	97.68
fisicaI_2022-23_74.xlsx	32.82	51.01	0.02	16.15	83.83	83.85
fisicaI_2022-23_75.xls	28.62	11.88	6.33	53.17	40.5	46.83
fisicaI_2022-23_76.xls	49.61	50.26	0.13	0.0	99.86	100.0
fisicaI_2023-24_01.xls	3.33	50.89	27.49	18.28	54.23	81.72

fisicaI_2023-24_02.xls	72.07	4.53	19.45	3.96	76.59	96.04
fisicaI_2023-24_03.xlsx	84.7	1.24	0.3	13.76	85.94	86.24
fisicaI_2023-24_04.xls	7.41	70.86	19.57	2.16	78.27	97.84
fisicaI_2023-24_05.xls	23.25	64.83	3.91	8.01	88.08	91.99
fisicaI_2023-24_06.xlsx	47.23	49.92	2.75	0.09	97.15	99.91
fisicaI_2023-24_07.xlsx	31.16	66.5	2.33	0.01	97.66	99.99
fisicaI_2023-24_08.xls	9.17	86.82	1.9	2.11	95.99	97.89
fisicaI_2023-24_09.xls	49.36	36.43	10.46	3.75	85.79	96.25
fisicaI_2023-24_10.xls	0.01	58.58	5.45	35.96	58.59	64.04
fisicaI_2023-	7.02	88.83	1.93	2.22	95.85	97.78

24_11.xlsx						
fisicaI_2023-24_12.xls	1.28	7.65	86.74	4.33	8.93	95.67
fisicaI_2023-24_13.xls	23.67	13.99	58.16	4.18	37.67	95.82
fisicaI_2023-24_14.xls	67.37	14.47	3.5	14.66	81.85	85.34
fisicaI_2023-24_15.xls	6.61	26.16	57.66	9.56	32.77	90.44
fisicaI_2023-24_16.xls	13.05	77.86	4.94	4.15	90.91	95.85
fisicaI_2023-24_17.xls	1.08	4.76	37.47	56.69	5.84	43.31
fisicaI_2023-24_18.xls	47.25	6.24	31.78	14.73	53.48	85.27
fisicaI_2023-24_20.xls	0.04	91.35	8.46	0.15	91.39	99.85
fisicaI_2023-24_21.xl	2.4	96.72	0.08	0.81	99.12	99.19

s						
fisicaI_2023-24_22.xls	35.37	0.61	26.78	37.24	35.98	62.76
fisicaI_2023-24_23.xls	34.57	49.76	2.01	13.65	84.34	86.35
fisicaI_2023-24_24.xls	5.77	73.72	0.0	20.51	79.49	79.49
fisicaI_2023-24_25.xls	7.2	62.74	18.46	11.6	69.94	88.4
fisicaI_2023-24_26.xls	1.05	78.45	2.95	17.55	79.5	82.45
fisicaI_2023-24_27.xls	95.03	4.05	0.53	0.4	99.07	99.6
fisicaI_2023-24_28.xls	12.21	86.73	0.4	0.66	98.95	99.34
fisicaI_2023-24_29.xlsx	85.27	5.4	9.2	0.13	90.67	99.87
fisicaI_2023-24_30.xls	53.58	13.29	16.19	16.94	66.87	83.06

fisicaI_2023-24_31.xls	67.45	29.06	0.39	3.1	96.51	96.9
fisicaI_2023-24_32.xls	0.01	1.0	30.21	68.78	1.01	31.22
fisicaI_2023-24_33.xls	21.23	44.03	32.65	2.09	65.27	97.91
fisicaI_2023-24_34.xls	27.78	59.86	11.96	0.4	87.64	99.6
fisicaI_2023-24_35.xls	1.46	4.92	83.06	10.56	6.38	89.44
fisicaI_2023-24_36.xls	81.91	4.71	9.91	3.46	86.62	96.54
fisicaI_2023-24_37.xls	35.95	53.28	7.63	3.14	89.23	96.86
fisicaI_2023-24_38.xlsx	9.52	66.89	15.06	8.52	76.41	91.48
fisicaI_2023-24_39.xlsx	53.62	12.59	33.68	0.11	66.21	99.89
fisicaI_2023-	25.97	44.45	23.3	6.28	70.42	93.72

24_40.xls						
fisicaI_2023-24_41.xls	10.99	73.59	2.23	13.19	84.58	86.81
fisicaI_2023-24_42.xls	8.69	91.22	0.08	0.02	99.9	99.98
fisicaI_2023-24_43.xls	3.61	69.24	25.28	1.87	72.85	98.13
fisicaI_2023-24_44.xlsx	13.67	86.12	0.11	0.1	99.79	99.9
fisicaI_2023-24_45.xls	45.42	28.83	8.75	17.0	74.25	83.0
fisicaI_2023-24_46.xls	0.63	87.18	7.36	4.83	87.81	95.17
fisicaI_2023-24_47.xls	0.6	0.01	96.41	2.98	0.61	97.02
fisicaI_2023-24_48.xls	3.15	92.67	1.27	2.9	95.83	97.1
fisicaI_2023-24_49.xl	10.45	2.76	16.21	70.59	13.2	29.41

sx						
fisicaI_2023-24_50.xlsx	0.15	95.58	4.13	0.14	95.73	99.86
fisicaI_2023-24_51.xls	4.08	27.79	58.36	9.77	31.87	90.23
fisicaI_2023-24_52.xlsx	51.77	0.01	44.09	4.13	51.78	95.87
fisicaI_2023-24_53.xlsx	80.68	16.63	1.88	0.81	97.32	99.19
fisicaI_2023-24_54.xlsx	18.15	5.66	53.02	23.16	23.82	76.84
fisicaI_2023-24_55.xls	24.04	22.68	52.32	0.96	46.72	99.04
fisicaI_2023-24_56.xls	11.96	3.7	3.15	81.19	15.66	18.81
fisicaI_2023-24_57.xlsx	31.06	4.53	23.09	41.32	35.59	58.68
fisicaI_2023-24_58.xls	64.82	32.55	2.0	0.62	97.37	99.38

fisicaI_2023-24_59.xls	94.14	4.67	1.14	0.06	98.81	99.94
fisicaI_2023-24_60.xlsx	97.27	1.28	1.4	0.06	98.55	99.94

2.3 Global analysis of the principal components

Figure 6 shows a three-dimensional representation of the learning styles of the students as a function of the contributions to three of the CHAEA learning styles. The tendency towards the remaining learning style is impliclity shown in the size and color shades of the points (bigger and darker colors imply a larger tendency). The principal directions shown as continuous lines (PC0 , red; PC1, green; PC2, purple; PC3, orange) emerge from centroid, which is given by the average mean of the data set and is shown as a black star. The projection of the points and the average mean is shown in gray. The projection confidence interval of the average mean is also shown. The origin, which is defined as (0, 0, 0, 0) in the 4D space of the learning styles is shown as a black triangle. The colored points correspond to the maximal pure learning styles (e.g., (20, 0, 0, 0) for activist (red), or (0, 20, 0, 0) for reflector (green)) are also marked.

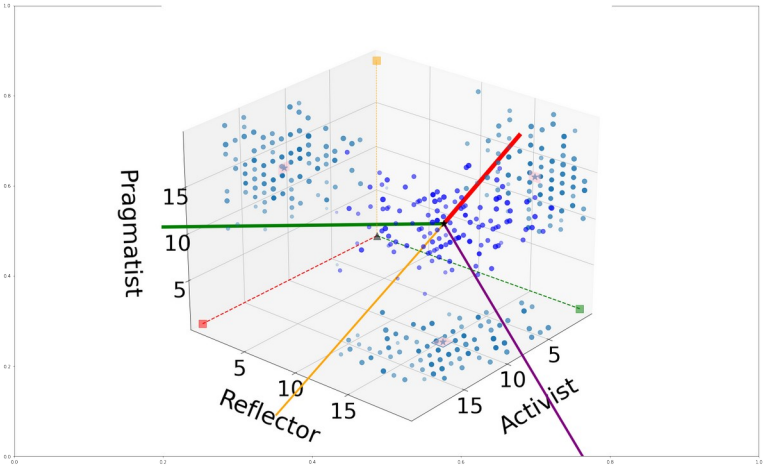

Figure 6. Three-dimensional representation of the learning styles of the students as a function of the CHAEA learning styles.

The central panel in Fig. 7 shows the projection of the learning styles of the student represented in Fig. 6 on the two main principal components (PC0 and PC1), along with their histograms. The data surround the average mean (gray star). The points (20, 0, 0, 0), (0, 20, 0, 0), (0, 0, 20, 0), and (0, 0, 0, 20), which correspond, respectively, to the maximal pure activist (red), reflector (green), theorist (purple), and pragmatist (orange) learning styles in the original basis set are also marked, and joined with a dashed line to the corresponding origin (0, 0, 0, 0) (black triangle). The point (20, 20, 20, 20) is also shown (brown diamond).

The reduced dimensional representation of the data given by Fig. 7 is usually meaningful if $\Sigma\_1(\%) \geq 70.0\%$; in the case under study we have that $\Sigma\_1(\%) = 92.0$. The top and left panels of Fig. 7 show the histrograms of the data as a function of PC0 (red) and PC1 (green), which are fitted using Weibull distributions with the parameters listed in Table 9.

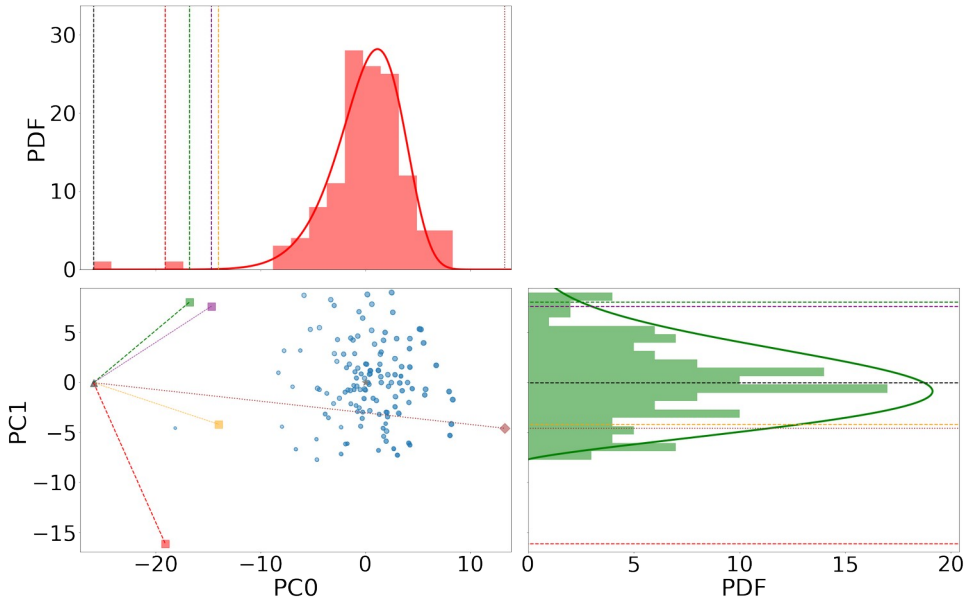

Figure 7. The projection of the learning styles of the students represented in Fig. 6 on the two main principal components (PC0 and PC1), along with their histograms as a function of PC0 (red) and PC1 (green).

Table 9. Parameters of the Weibull distributions that fit the probability distributions (histograms) of the projection of the learning styles on the principal-components basis set (see histograms in Fig. 7). The location parameter θ is set equal to the smallest projection for each component.

Principal component	α	k	θ
0	27.4	9.54	-25.92
1	8.87	2.25	-7.72
2	6.74	3.03	-5.96
3	7.51	4.95	-6.99

3. Participation ratios

Third, the participation ratios are finally presented in Section 3. The values for the CHAEA (active, theorist, pragmatic, and reflector) and for the principal-components basis sets are listed. To conclude, a statistical analysis of the distribution of the participation ratios is performed.

3.1 Individual analysis of the participation ratios

Table 10 shows the participation ratios of each individual student for CHAEA (active, theorist, pragmatic, and reflector) and for the principal-components basis sets. For the case under study, this parameter lies between 1 and 4. The smaller the participation ratio, the better.

Table 10. Participation ratios of each individual student for CHAEA learning styles (LS) and for the principal-components (PC) basis sets.

Student	LS	PC
fisicaI_2022-23_01.xls	3.98	2.02
fisicaI_2022-23_02.xls	3.31	1.18
fisicaI_2022-23_03.xls	3.94	2.32
fisicaI_2022-23_04.xlsx	2.96	3.58
fisicaI_2022-23_05.xlsx	3.63	2.51
fisicaI_2022-23_06.xls	3.71	2.33
fisicaI_2022-23_07.xlsx	3.5	1.8
fisicaI_2022-23_08.xls	3.21	2.47
fisicaI_2022-23_09.xls	3.22	1.68
fisicaI_2022-23_11.xls	3.85	1.86
fisicaI_2022-23_12.xls	3.89	1.95
fisicaI_2022-23_13.xlsx	3.84	1.79
fisicaI_2022-23_14.xls	2.31	2.63
fisicaI_2022-23_15.xlsx	3.8	1.08
fisicaI_2022-23_17.xls	3.48	2.21
fisicaI_2022-23_18.xls	3.19	2.56

fisicaI_2022-23_19.xls	3.65	2.48
fisicaI_2022-23_20.xls	3.86	2.03
fisicaI_2022-23_21.xls	3.77	1.83
fisicaI_2022-23_22.xlsx	3.42	2.22
fisicaI_2022-23_23.xls	3.44	3.23
fisicaI_2022-23_24.xls	3.59	1.65
fisicaI_2022-23_25.xls	3.7	3.15
fisicaI_2022-23_26.xls	3.61	2.43
fisicaI_2022-23_27.xls	3.65	1.59
fisicaI_2022-23_30.xls	3.49	1.32
fisicaI_2022-23_31.xls	3.34	3.32
fisicaI_2022-23_33.xlsx	3.56	2.77
fisicaI_2022-23_34.xls	3.21	2.48
fisicaI_2022-23_35.xls	2.9	1.92
fisicaI_2022-23_36.xls	3.63	1.6
fisicaI_2022-23_37.xls	3.48	3.34
fisicaI_2022-23_38.xlsx	2.86	1.56
fisicaI_2022-23_39.xls	2.81	1.17
fisicaI_2022-23_40.xls	3.03	1.47
fisicaI_2022-23_41.xls	3.75	1.92
fisicaI_2022-23_42.xls	3.58	3.93
fisicaI_2022-23_43.xls	3.54	1.37
fisicaI_2022-23_44.xls	3.89	1.8
fisicaI_2022-23_45.xlsx	3.89	2.21
fisicaI_2022-23_46.xls	3.04	2.86

fisicaI_2022-23_47.xls	3.5	1.82
fisicaI_2022-23_48.xls	3.24	2.11
fisicaI_2022-23_49.xls	3.75	1.97
fisicaI_2022-23_50.xls	2.77	1.03
fisicaI_2022-23_51.xls	2.4	1.77
fisicaI_2022-23_52.xls	3.08	1.81
fisicaI_2022-23_53.xlsx	3.67	1.62
fisicaI_2022-23_54.xlsx	3.58	3.93
fisicaI_2022-23_55.xls	3.58	1.51
fisicaI_2022-23_56.xls	3.16	2.02
fisicaI_2022-23_57.xls	3.95	1.78
fisicaI_2022-23_58.xlsx	3.64	2.67
fisicaI_2022-23_59.xls	2.78	2.04
fisicaI_2022-23_61.xls	3.92	2.13
fisicaI_2022-23_62.xls	3.42	2.79
fisicaI_2022-23_63.xlsx	3.52	2.97
fisicaI_2022-23_64.xlsx	3.06	1.1
fisicaI_2022-23_65.xls	3.54	1.32
fisicaI_2022-23_66.xls	2.51	1.52
fisicaI_2022-23_67.xls	3.78	2.1
fisicaI_2022-23_68.xls	3.54	3.37
fisicaI_2022-23_69.xls	3.85	1.35
fisicaI_2022-23_70.xls	2.94	2.1
fisicaI_2022-23_71.xls	1.0	1.08
fisicaI_2022-23_72.xls	3.71	2.52
fisicaI_2022-23_73.xls	3.76	1.38

fisicaI_2022-23_74.xlsx	2.73	2.54
fisicaI_2022-23_75.xls	3.79	2.61
fisicaI_2022-23_76.xls	3.26	2.01
fisicaI_2023-24_01.xls	3.63	2.71
fisicaI_2023-24_02.xls	3.51	1.78
fisicaI_2023-24_03.xlsx	3.85	1.36
fisicaI_2023-24_04.xls	3.71	1.83
fisicaI_2023-24_05.xls	2.94	2.07
fisicaI_2023-24_06.xlsx	3.23	2.11
fisicaI_2023-24_07.xlsx	3.3	1.85
fisicaI_2023-24_08.xls	3.52	1.31
fisicaI_2023-24_09.xls	3.91	2.57
fisicaI_2023-24_10.xls	3.41	2.1
fisicaI_2023-24_11.xlsx	3.18	1.26
fisicaI_2023-24_12.xls	3.54	1.32
fisicaI_2023-24_13.xls	2.86	2.41
fisicaI_2023-24_14.xls	3.79	2.01
fisicaI_2023-24_15.xls	3.04	2.41
fisicaI_2023-24_16.xls	3.14	1.59
fisicaI_2023-24_17.xls	3.48	2.15
fisicaI_2023-24_18.xls	3.47	2.86
fisicaI_2023-24_20.xls	2.8	1.19
fisicaI_2023-24_21.xls	3.09	1.07
fisicaI_2023-24_22.xls	3.22	2.98
fisicaI_2023-24_23.xls	3.52	2.59
fisicaI_2023-24_24.xls	3.51	1.7

fisicaI_2023-24_25.xls	3.77	2.24
fisicaI_2023-24_26.xls	2.98	1.54
fisicaI_2023-24_27.xls	3.92	1.11
fisicaI_2023-24_28.xls	2.92	1.3
fisicaI_2023-24_29.xlsx	2.51	1.35
fisicaI_2023-24_30.xls	3.84	2.78
fisicaI_2023-24_31.xls	3.83	1.85
fisicaI_2023-24_32.xls	3.25	1.77
fisicaI_2023-24_33.xls	3.8	2.89
fisicaI_2023-24_34.xls	3.76	2.22
fisicaI_2023-24_35.xls	3.18	1.42
fisicaI_2023-24_36.xls	3.83	1.46
fisicaI_2023-24_37.xls	3.41	2.38
fisicaI_2023-24_38.xlsx	3.23	2.06
fisicaI_2023-24_39.xlsx	3.71	2.4
fisicaI_2023-24_40.xls	3.42	3.09
fisicaI_2023-24_41.xls	2.76	1.75
fisicaI_2023-24_42.xls	3.7	1.19
fisicaI_2023-24_43.xls	3.07	1.84
fisicaI_2023-24_44.xlsx	2.59	1.32
fisicaI_2023-24_45.xls	3.37	3.07
fisicaI_2023-24_46.xls	2.58	1.3
fisicaI_2023-24_47.xls	3.73	1.07
fisicaI_2023-24_48.xls	3.69	1.16
fisicaI_2023-24_49.xlsx	3.59	1.86
fisicaI_2023-24_50.xlsx	2.99	1.09

fisicaI_2023-24_51.xls	3.45	2.33
fisicaI_2023-24_52.xlsx	3.81	2.15
fisicaI_2023-24_53.xlsx	3.6	1.47
fisicaI_2023-24_54.xlsx	3.82	2.7
fisicaI_2023-24_55.xls	3.71	2.61
fisicaI_2023-24_56.xls	3.7	1.48
fisicaI_2023-24_57.xlsx	3.73	3.1
fisicaI_2023-24_58.xls	3.4	1.9
fisicaI_2023-24_59.xls	3.88	1.13
fisicaI_2023-24_60.xlsx	3.86	1.06

3.2 Global analysis of the participation ratios

Figure 8 shows the probability distribution functions of the participation ratios for the learning-styles basis set (red) and for the principal components (blue). The vertical dashed lines mark the average means along with their corresponding confidence intervals (shaded areas), whose values can be found in Table 11. The corresponding cumulative distributions used in the fitting are shown in Fig. 9.

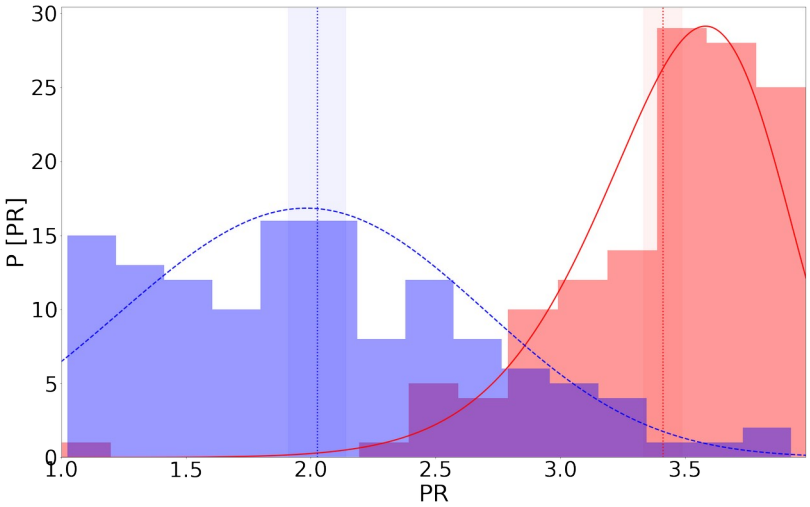

Figure 8. Probability distribution functions of the participation ratios associated with the learning-styles basis set (red) and with the principal components (blue). The vertical dashed lines mark the average means along with their corresponding confidence intervals (shaded areas), whose values can be found in Table 11. The continuous lines show fitting functions given by Weibull distributions with parameters shown in Table 11.

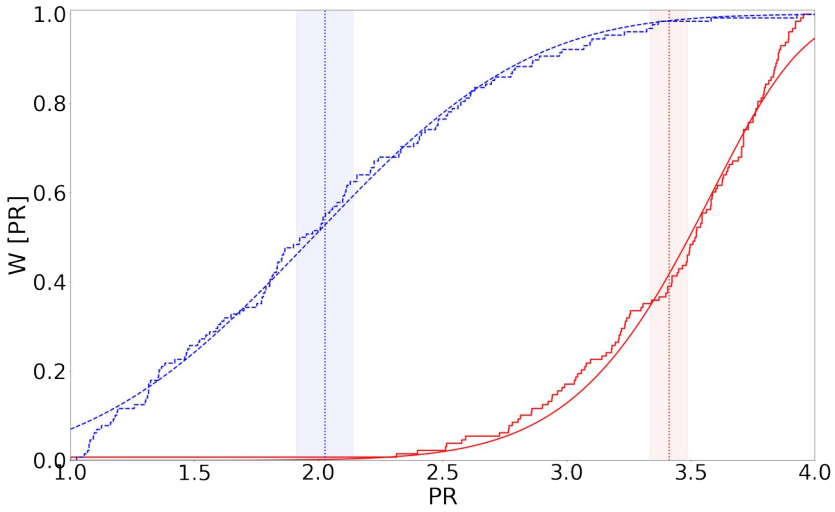

Figure 9. Cumulative distributions for the results of Fig. 8.

Table 11. Average mean and corresponding uncertainty (in parenthesis) of the participation ratios for the learning-styles basis set and for the principal components. α and k are, respectively, the shape and scale parameters of the Weibull distributions the fit the probability distributions (histograms) of Fig. 8. The location parameter is set equal to θ = 0.

Basis set	Average mean (Uncertainty)	α	k
Principal component	3.41(0.07)	3.62	10.62
Learning styles	2.03(0.11)	2.21	3.31