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Rasch Analysis for Electric Circuits*

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We show some results on physics education research about rasch analysis and active learning for electrical circuits with high school students, developed in one school of Mérida, Yucatán at the South of México. The active learning methodologies are important, because there are good results in the literature about their implementation in different educational levels. Besides, it is a way to innovate the physics class, unfortunately in the Latin America region their effectiveness has been little studied. This brief report sheds more light on the matter.

Keywords: active learning, rasch model, electrical circuits

Active Learning of Physics

The active learning of physics (Mintzes & Walter, 2020), in the last 30 years has been one of the most important teaching methodologies because of the excellent results in the students learning. In this work, we present one application of active learning of physics for high school students in a Mexican school, we make a rasch analysis for the learning of electrical circuits. This work pretends to give us some light in the assessment of active learning methodologies of physics (Sokoloff, Thornton, & Laws, 1998; Thornton & Sokoloff, 1998).

The rasch model (Boomsma, van Duijn, & Snijders, 2001), is especially useful for visualize the results, using item characteristics curves (ICC). This can help us to analyze the improvement of the groups, when we use active learning of physics methodologies.

The paper is organized as follows. In the following sections, we show how the active learning of physics can be implemented in a high school, also we include the respective rasch model analysis. Finally, we present our conclusions.

In the state of Yucatán in México, the average level of education of the population aged 15 years and over is 8.8, which is equivalent to a little more than a second year of secondary school. National average: 9.2 of every 100 people aged 15 and over (Instituto Nacional de Estadística y Geografía, 2018):

1. They do not have degree of schooling: 6.7;
2. They have finish basic education: 55.0;
3. They finish upper secondary education: 19.9;

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4. They concluded higher education: 18.2;
5. Not specified: 0.2.

Table 1

School Modality: Educational Indicators in Yucatán

Higher middle education	2015-2016 (%)	2016-2017 (%)	2016-2017 National (%)	2017-2018 (%)	2017-2018 National (%)
Dropping out of school	14.1	13.9	13.0	17.7	12.3
Reprobation	19.0	18.6	13.9	18.3	13.4
Terminal efficiency	60.6	62.2	67	64.1	66.6

Table 1 resumes the information of levels of education in Yucatán and the rest of México (data taken from "Instituto Nacional de Estadística y Geografía" of México). We will analyze the results of learning electrical circuits in a high school (Rodríguez, 2019), where the teaching of physics is given in a traditional way, i.e., is based on the unidirectional instruction where the teacher exposes, explains, and solves problems. We propose then active learning based on Sokoloff and Laws (2012), method of prediction, observation, discussion, and synthesis (PODS) cycleand the interactive lecture demonstrations (Sokoloff & Thornton, 2006), together with an electrical circuit prototype (built by the students themselves) as support material for the didactic activity. The theme of study is electricity, Ohm's law and the elemental series and parallel circuits. We then employ a didactic prototype to teach electrical circuits to the students. In this work, we have a control group and an experimental group, the last of which will have, the last of which will have instruction with the help of active learning. We explore our results employing again, the rasch model.

Rasch Model for Active Learning of Physic in the Xoclán High School in Yucatán, México

The parameters of easiness are show in Tables 2 and 3. We can note that the two groups have a progress in their knowledge of the electrical circuits. We have employed two packages of software called "ERM" (extended rasch modeling) and "LTM" (Latent Trait Models), from the "R" programming language (Baker & Kim, 2017).

Table 2

Easiness Parameters and Difference Between Pre-Test and Post-Test Phases of the Sample in Control Group

Item	Pre-test	Post-test	Difference	Criteria
Q1	-0.685	0.066	0.751	Medium
Q2	-0.144	0.878	1.022	Medium
Q3	-0.144	-	-	-
Q4	-	-1.248	-	-
Q5	-0.685	-1.248	-0.563	Medium
Q6	0.706	1.266	0.560	Medium
Q7	-0.685	-0.455	0.230	Medium
Q8	0.300	-1.248	-1.548	Hard
Q9	1.549	1.691	0.142	Medium
Q10	0.706	0.066	-0.640	Medium
Q11	-0.144	0.066	0.210	Medium
Q12	-0.685	0.066	0.751	Medium
Q13	-0.685	0.750	1.435	Medium
Q14	0.300	0.620	0.320	Medium
Q15	0.300	0.660	0.360	Medium

The applied test was based in 13 questions of Electric Circuits Conceptual Evaluation (ECCE) test (Retrieved from https://www.physport.org) and two questions from a local book named “Physics II” (used in the Xoclan Plantel in Yucatán, México). In total, 15 questions were applied in the two phases (pre-test and post-test).

If we examine Table 2, for example, we see that the easiness parameters of the post-test in the control group are in general mayor that the corresponding parameters for the pre-test, this can be easily seen from Table 2.

In Table 3, we see that also the experimental group improves with the active learning. Some of the values cannot be computed by numerical methods (Fischer & Molenaar, 1995), because some columns or rows have only one value (0 or 1), which represent one irregularity in the data set.

Table 3

Easiness Parameters and Difference Between Pre-Test and Post-Test Phases of the Sample in Experimental Group

Item	Pre-test	Post-test	Difference	Criteria
Q1	0.066	1.016	0.950	Medium
Q2	0.878	1.016	0.138	Medium
Q3	-	1.016	-	-
Q4	-1.248	-1.153	0.095	Medium
Q5	-1.248	0.213	1.461	Medium
Q6	1.266	-	-	-
Q7	-0.455	-1.546	-1.091	Medium
Q8	-1.248	-	-	-
Q9	1.691	-	-	-
Q10	0.066	1.016	0.950	Medium
Q11	0.066	-0.320	-0.386	Medium
Q12	0.066	1.016	0.950	Medium
Q13	-0.455	0.213	0.668	Medium
Q14	0.490	-0.320	-0.810	Medium
Q15	0.066	-	-	-

We continue the analysis plotting the ICC in each case and comparing the results. The probabilities of a correct response in Figures 1b and 2b were raised with respect to the pre-test phase (Figures 1a and 2a).

Showing in a graphical form that the group of control in post-test have improved their punctuation, because the curves in post-test show comparatively more probability of a correct response that the corresponding curves of the control group in their pre-test phase.

The same situation is repeated in a similar way for the pre-test *vs*. post-test phases for the experimental group. Nevertheless, the heights of the curves in post-test phase for the experimental group are comparatively greater than the heights of the heights of the curves of the post-test phase for the control group. Here, we finalize our analysis of our results by using the rrasch model.

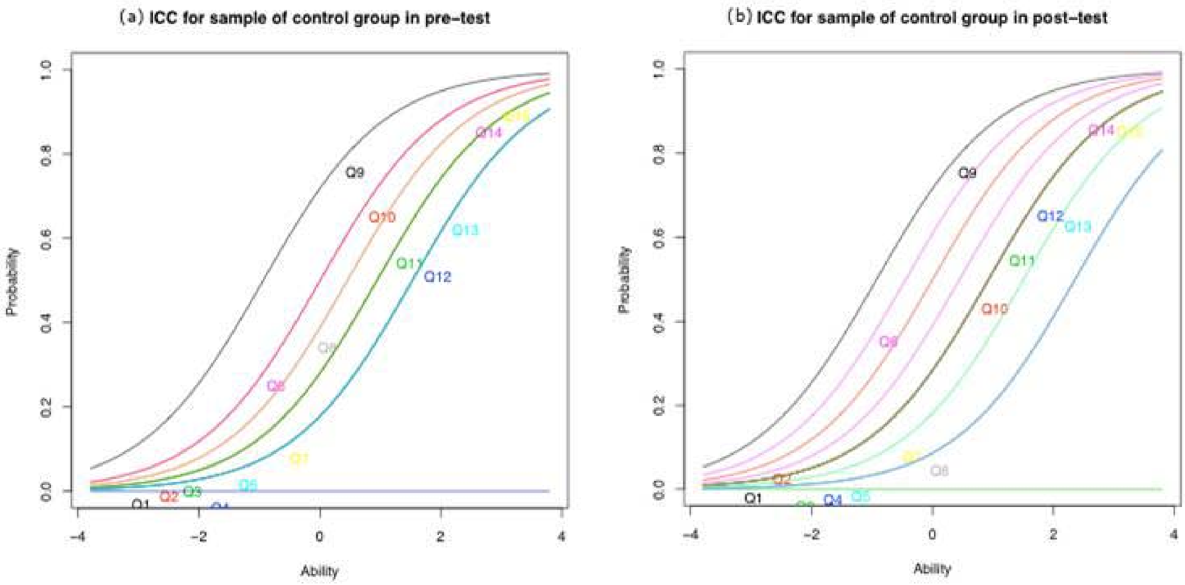

Figure 1a-b. ICC for the sample of the control group of the Xoclán Plantel in Yucatán, México. 1a. In pre-test phase. 1b. In post-test phase. The probability of success in each item is show.

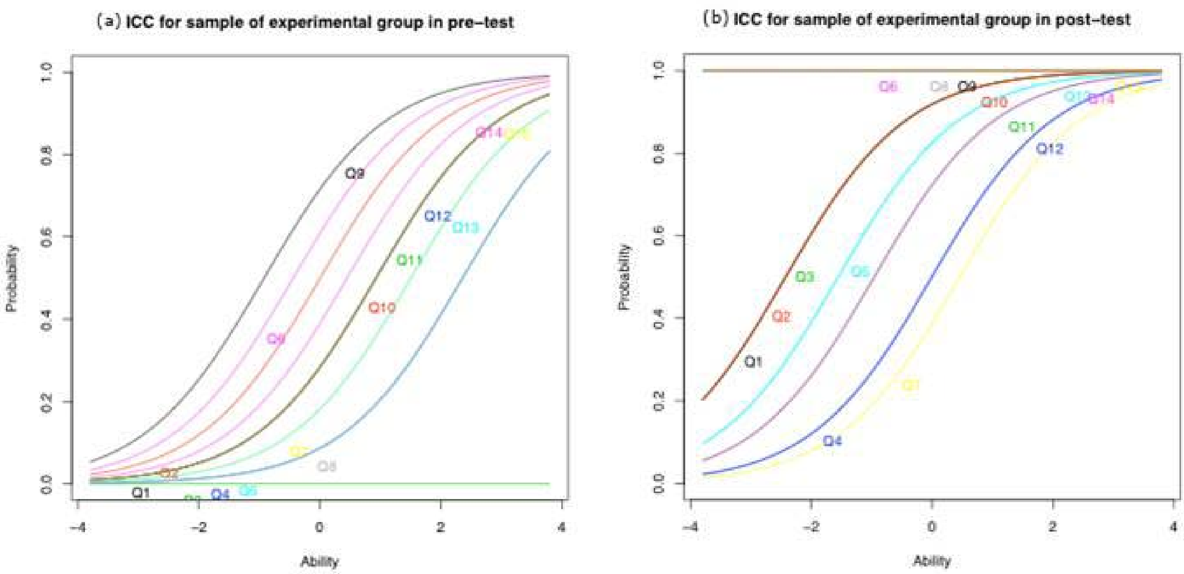

Figure 2a-b. ICC for the sample of the experimental group of the Xoclán Plantel in Yucatán, México. 2a. In the pre-test phase. 2b. In post-test phase. The probability of success in each item is show.

Conclusion

We have used the rasch model to show the effectiveness of active learning of physics with the PODS cycle and the interactive lecture demonstrations applied in a high school in Merida, Yucatán, México. We study the electrical circuits in series and in parallel with a prototype armed by the students. We clearly appreciate the advantage of applying the methodology used by Sokoloff and Thornton (2006) and Sokoloff and Laws (2012). The advantage is evident from the graphs of item response curves for the items of the respective tests applied in each case.

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