

Experiments in selection processes of students for a crammer

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XVI Latin American Conference on Learning Technologies (LACLO)
From 19 to 21 October 2021, Arequipa - Perú

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Motivation

- How to select candidates for a crammer?
 - Classical Test Theory (CTT)
 - Using a Item Response Theory (IRT)
 - Etc.
- How to compare these two methods?
 - Analyzing the two methods of ranking each candidate
 - Analyzing success statistics for each question
- Therefore, our approach tries to discuss the fairness of the tie-breaking criteria

Theoretical Fundamentals of IRT

- We adopt the 3PLM (three-parameter a, b and c logistic model) that computes the probability of the j th candidate's answer to be correct for a given dichotomous item i .

$$P(X_{ij} = 1|\theta_j) = c_i + \frac{1 - c_i}{1 + e^{-Da_j(\theta_j - b_i)}}$$

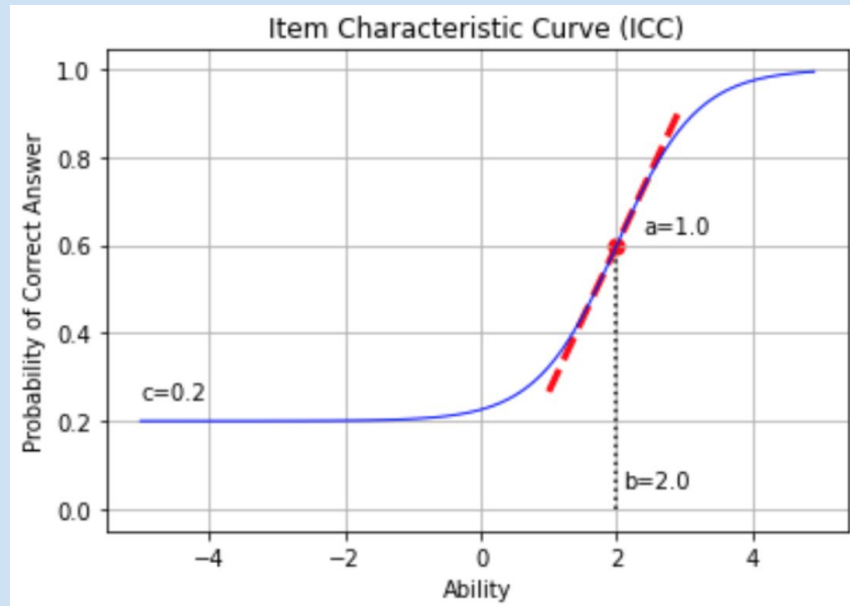
a - discrimination

b - ability

c - causality

Theoretical Fundamentals of IRT

$$P(X_{ij} = 1|\theta_j) = c_i + \frac{1 - c_i}{1 + e^{-Da_j(\theta_j - b_i)}}$$



$a=1$ - discrimination

$b=2$ - ability

$c=0.2$ - causality

X_{ij} = matrix of responses from all candidates j

Try other values: [Colab](#)

Methodology

- We have developed three frameworks in Python and R programming languages on Google Colab to carry out IRT vs TCC analyses.
 - A. Classroom Selection Processes of 2019 and 2020
 - B. Online Selection Process of 2021
 - C. ENEM's Exam of 2019

Available in <http://vision.ufabc.edu.br/MCTest/public/IRT2021>

Methodology: A. Classroom Selection Processes of 2019 and 2020

- 50 five-choice questions comprising five subjects and three hours of duration:
 1. Human Sciences (HS)
 2. Natural Science (NS)
 3. Regulations/English-Spanish-Portuguese (or Languages and Codes - LC)
 4. Mathematics (MT)
 5. Writing an essay (EW)
- Using MCTest available in <http://vision.ufabc.edu.br>
 - Print PDF file for each candidate
 - Automatic correction using Computer Vision techniques

Methodology: B. Online Selection Process of 2021

- 50 five-choice questions comprising the same five subjects
- 5 days, in which candidates had 24 hours to solve 10 questions per subject
- Using Moodle

Methodology: C. ENEM's Exam of 2019

- 45 five-choice questions comprising four subjects and three hours of duration:
 1. Human Sciences (HS)
 2. Natural Science (NS)
 3. Regulations/English-Spanish-Portuguese (or Languages and Codes - LC)
 4. Mathematics (MT)
- 2 days, in which candidates had 4 hours to solve 90 questions in two subjects

Results and Discussion

- CSP (crammer selection process)
 - CSP2019
 - 2,033 candidates
 - 633 were selected
 - CSP2020
 - 2,043 candidates
 - 633 were selected

Results and Discussion

- CSP (crammer selection process)
 - CSP2021
 - afternoon (1,022 candidates)
 - evening (1,746 candidates)
 - 190 were selected for each period

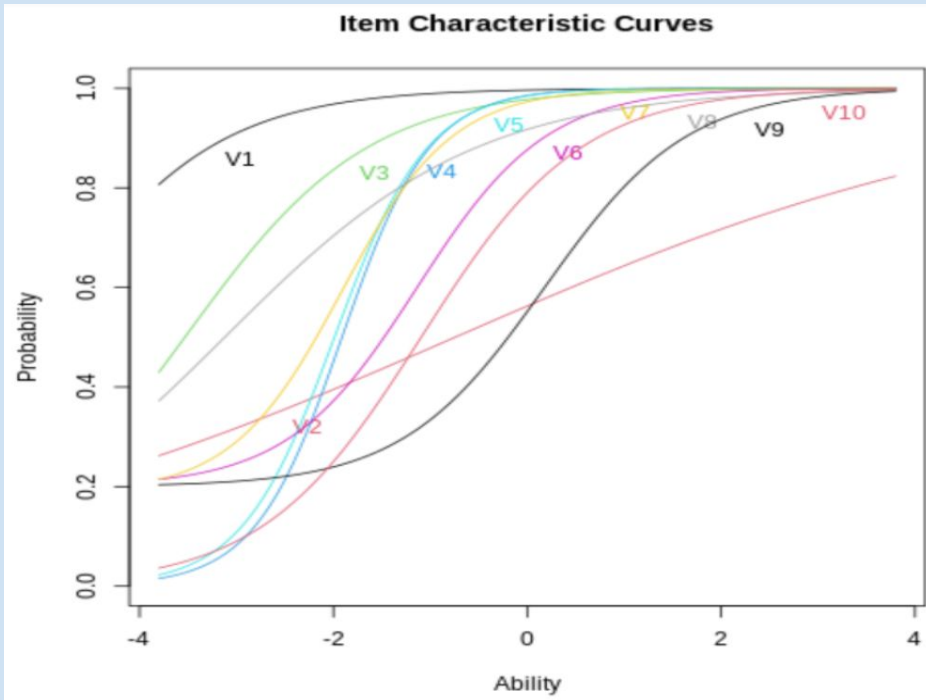
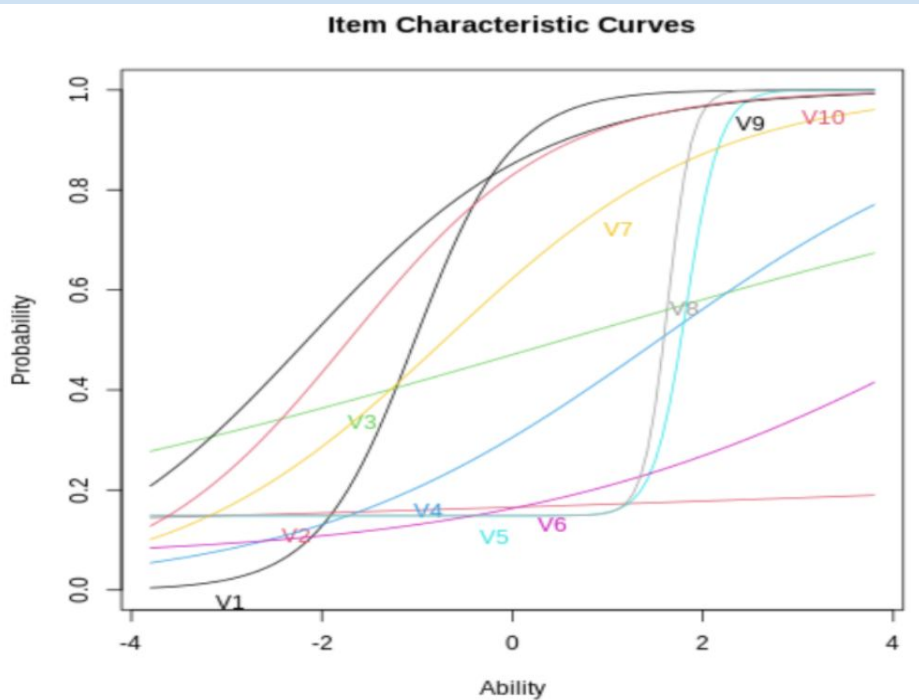
Subject	day (afternoon)	answers	day (evening)	answers	Total
MT	1	491	4	892	1383
HS	3	514	1	913	1427
NS	2	510	5	867	1377
PG	4	506	2	933	1439
LC	5	502	3	925	1427

Results and Discussion

- ENEM 2019
 - 5.1 million candidates in a 3.2GB CSV files
 - Zip file available in [INEP](#)
 - 2,000 samples per subject

Results and Discussion: CSP (crammer selection process)

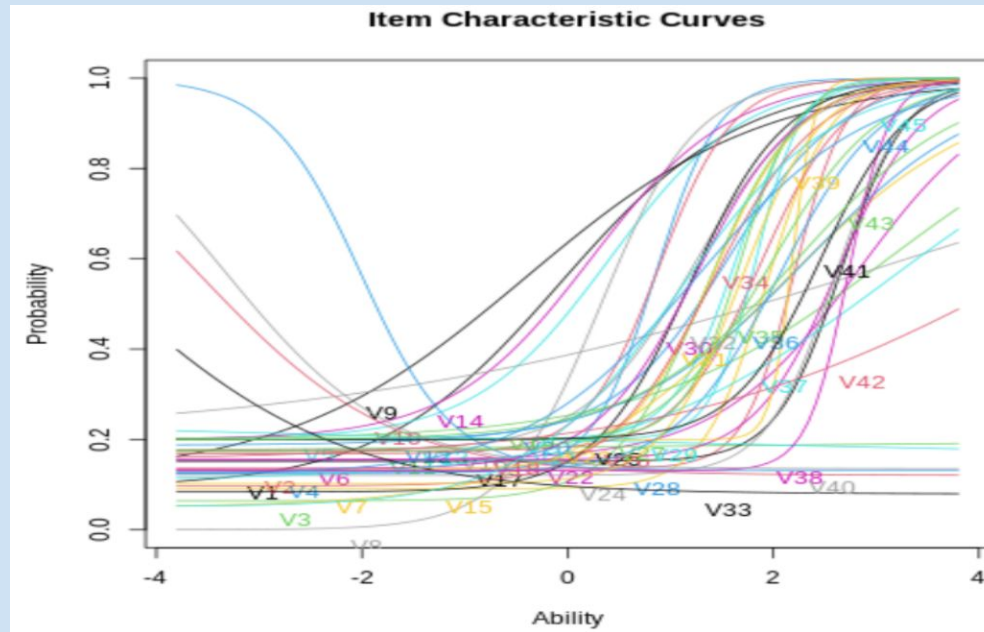
Item Characteristic Curves (ICC) for Maths regarding **CSP2019** and **CSP2021**



CSP2019 and **CSP2021** \Rightarrow the second is easier

Results and Discussion: ENEM 2019

Item Characteristic Curves (ICC) for Maths regarding **ENEM2019**



ENEM2019 ⇒ this one is much harder

Results and Discussion

MEANS AND STANDARD DEVIATIONS IN 2019, 2020 (MCTEST) AND 2021 (MOODLE) COMPARED WITH ENEM2019 (YELLOW EXAM).

Subject	Mean (2019)	STD (2019)	Mean (2020)	STD (2020)	Mean (2021)	STD (2021)	Mean-ENEM (2019)	STD-ENEM (2019)
MT	0.45	0.50	0.61	0.49	0.83	0.37	0.26	0.44
HS	0.60	0.49	0.73	0.44	0.89	0.31	0.37	0.48
NS	0.38	0.48	0.53	0.50	0.93	0.26	0.29	0.45
LC	0.43	0.49	0.55	0.50	0.90	0.30	0.37	0.48
PG	0.68	0.47	0.44	0.50	0.85	0.36		

⇒ CSP 2019-2020 is the average

⇒ CSP 2021 is easy

⇒ ENEM is difficult

Results and Discussion

CORRELATIONS BY SUBJECT IN 2019, 2020 (MCTEST) AND 2021 (MOODLE), BESIDES ENEM2019 (YELLOW EXAM).

Subject	CSP2019	R	CSP2020	R	CSP2021	R	ENEM2019	R
MT	2033	0.86	2043	0.87	1383	0.86	1994	0.88
HS	2033	0.97	2043	0.93	1427	0.89	1985	0.96
NS	2033	0.92	2043	0.95	1377	0.93	1994	0.90
LC	2033	0.96	2043	0.92	1439	0.90	1985	0.89
PG	2033	0.99	2043	0.94	1427	0.94		

⇒ The average correlations (R) between CTT and IRT is $R \cong 0.9\%$

Results and Discussion

- CSP2021 with CTT:
 - It happened that 54 and 107 candidates scored 50 and 49 (out of 50), respectively.
 - Due to there being only 130 places in the evening class, **we sorted these 107 by age**
- If we had used IRT:
 - **reduced 107 to only 9**

Conclusions

- How to select candidates for a crammer?
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Future Work

- We intend to adjust the items that do not present a standard ICC.
- We **offer free training** so that this method can be used by more people:
 - install MCTest in different institutions
 - for teachers to use

Thanks!

Questions?

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