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METHODOLOGY FOR IDENTIFYING CURRICULAR WEAKNESSES FROM ENADE COURSE REPORT: PERFORMANCE OF A PHYSICS DEGREE IN ENADE 2021

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Abstract: It is understood that the National Student Performance Exam (ENADE) makes it possible to analyze curricular weaknesses capable of supporting the improvement of curricular structures. A methodology is proposed to identify these weaknesses per observation unit (OU), based on the ENADE course report. The method is exemplified, focusing on 27 objective questions (64% of the grade) from the specific component (CE) of ENADE 2021 for a degree in Physics, in which the trainees showed themselves committed to the Exam (74% stayed more than 3 hours). Four items were disregarded, due to a discrimination rate of less than 20%, consolidating the analysis into 26 distractors that attracted at least 20% of respondents. Three items are exemplified that consolidate weaknesses linked to basic mechanics and other items that materialized difficulties in Practice in Physics Teaching and Inclusion are highlighted. It is understood that this systematic analysis can contribute as a subsidy in studies of curricular changes in Undergraduate courses.
Keywords: Degree in Physics, ENADE, Analysis Methodology, Course Report, Distractors

INTRODUCTION

The evaluation of higher education courses in Brazil is part of the National Higher Education Evaluation System (SINAES), implemented in 2004, with the aim of regulating and qualifying Higher Education. The Ministry of Education (MEC) monitors Higher Education Institutions (HEIs) and their courses, and it is a legitimate concern for HEIs to adapt to the Ministry's requirements. One of the components of SINAES, the National Student Performance Exam (ENADE), evaluates the performance of students completing undergraduate courses and is structured based on content, skills and abilities provided for in the National Curricular Guidelines (DCN) of the courses.

ENADE is carried out by the National Institute of Educational Studies and Research Anísio Teixeira (INEP), with the technical support of Area Advisory Committees, responsible, among other aspects, for the outlines and guidelines for consolidating the Bank of questions in the area, prepared by a body of experts. The National Bank of Items (BNI) for Higher Education is conceived, according to Griboski (2012), as a collection of questions prepared from matrices of content, skills and abilities pre-defined by the Area Advisory Committees, which allow the assembly of tests that estimate students' proficiency as accurately as possible.

Each annual edition of the Exam is regulated by a general Ordinance that explains the areas to be evaluated and the contours of student registration and participation and by specific Ordinances per assessment area, for which evaluation guidelines are established, which constitute documents of reference for HEIs and students assessed in the Exam. Each area Advisory Committee defines a Reference Matrix (MR) of the tests, which according to Rabelo (2011) materializes as a central and guiding instrument for the elaboration of items, in large-scale evaluation processes. In ENADE, MR crosses Resources (Capabilities) with Aspects of the Professional Profile, the Objects of Knowledge (Contents), the types of items and the assumed difficulty of the questions.

The ease index of ENADE's objective items is known when the result is released by the MEC of the Summary Report of the Exam by Area which, among other aspects, presents the required elements (profile aspect, resource, object(s) of knowledge) in each item, classifies the questions according to the percentage of correct answers as very easy (≥ 86%), easy (from 61% to 85%), medium

(from 41% to 60%), difficult (from 16% to 40%) and very difficult (≤15%). Furthermore, the Report presents the discrimination index (biserial point) of the items, with items with a discrimination index lower than 20% being disregarded when calculating the ENADE concept. Table 1 summarizes the composition of the exam grade.

The ENADE concept is configured as a determining quality indicator in the composition of the Preliminary Course Concept (CPC), the regulatory indicator for the renewal of recognition of Undergraduate courses. The two quality indicators, the ENADE Concept and the CPC, are calculated per Observation Unit (OU). An Exam OU consists of an assessment area of a Higher Education Institution (HEI), in a municipality. Both ENADE and CPC are classified by OU in bands from 1 to 5, based on calculations based on standardized national averages, by component of the indicator, and by standardized departures from the national standard deviation of the area. Details of this calculation are explained in INEP (2022).

Due to the relevance of ENADE in the context of Higher Education regulation, there is a growing interest among researchers and university professors in understanding its complexity, such as Cavalcante et al. (2009), Higa et al. (2010, 2012), Costa & Martins (2014) propose a Reference Matrix for the editions of ENADE (2005, 2008, 2011). Other works seek to understand distractors (wrong alternatives) in objective Physics questions in ENADE [Martins & Costa (2016)] as well as in ENEM authors [Marcom & Kleinke (2016), Duarte & Martins (2020)]. This research formalizes a methodology for identifying these curricular weaknesses in an observation unit (OU), based on its ENADE course report.

The aim, therefore, is to describe an analysis methodology, exemplified in a specific case, substantiated in the understanding that such weaknesses (conceptual or procedural) can support, in addition, based on the students' performance in the test, the review of curricular structures.

DEVELOPMENT

27 (twenty-seven) objective questions from the ENADE 2021 CE for a Degree in Physics were considered in this investigation, observing the performance of graduating students, through their Course Report available at https://enade.inep.gov. br/enade/#! /relatorioCursos

It is understood that the chosen OU enables the intended analysis, as the lack of significant commitment of the trainees, especially due to their length of stay in the Exam, is not observed in the perception questionnaire about the test, available in the respective course report. In fact, in this UO, the time spent on the test in more than three hours (74% of those completing the test) significantly exceeds the national average (58%).

The test and its answer sheet are available at https://www.gov.br/inep/pt-br/areas-de-atuacao/avaliacao-e-exames-educacionais/enade/provas-e-gabaritos.

The 27 (twenty-seven) objective questions of the Specific Component (CE) are distributed in 4 (15%) interpretation items, with a problem situation and five alternatives and 23 (85%) multiple response items, with a format of multiple statements (1 item uses 2 statements, 11 items uses 3 statements, 9 items uses 4 statements, and 2 items uses 5 statements) where the alternatives represent a composite of these statements. This preferential format of alternatives is understood to be due to the difficulty of constructing problem situations that allow, in addition to the correct alternative, 4 distractors that constitute plausible wrong alternatives, that is, possible results to be achieved, based on mistaken premises.

In addition to the test, the table of the

Component	Component Weight	Type of question	# of questions	Weight of questions	
				Component	Proof
General formation	25%	Discursive	2	40%	10,00%
		Objective	8	60%	15,00%
Specific	75%	Discursive	3	15%	11,25%
		Objective	27	85%	63,75%
Total	100%	Total	40	Total	100,00%

Table 1: Composition of ENADE 2021

Source: INEP (2022)

respective Course Report for the UO on screen shows, per question in the columns on the left, the comparison between the course's success percentages and other broader results, such as the state (UF), the region and country. Next, the table shows the column that represents the answer key (correct answer) and in the columns on the right the distribution of the responses of the graduates, in percentages per alternative, in the objective questions of the Specific Component. (Table 2)

	Hit Percentage							Course Response				
Question	Course	UF	Region	Cat. Adm.	Org. Acad.	Brazil	Template	A	B	C	D	E
9	-	-	-	-	-	-	**	-	-	-	-	-
10	60,0	35,2	35,8	29,5	33,1	32,0	D	0,0	0,0	10,0	60,0	30,0
11	50,0	52,1	54,0	46,5	48,0	44,9	D	25,0	10,0	10,0	50,0	5,0
12	55,0	48,6	51,8	47,9	47,2	44,8	D	20,0	10,0	15,0	55,0	0,0
13	20,0	32,4	30,5	25,7	27,2	25,8	A	20,0	35,0	25,0	20,0	0,0
14	65,0	50,3	50,7	40,0	49,6	46,4	B	10,0	65,0	5,0	20,0	0,0
15	45,0	36,2	37,1	31,5	37,3	34,7	D	5,0	20,0	5,0	45,0	20,0
16	20,0	46,2	46,5	38,0	44,0	41,2	A	20,0	5,0	55,0	5,0	15,0
17	45,0	40,0	40,3	36,7	39,0	36,0	C	40,0	0,0	45,0	0,0	15,0
18	90,0	68,6	66,8	56,8	65,1	62,3	C	0,0	0,0	90,0	0,0	10,0
19	10,0	20,0	20,2	18,1	20,0	19,9	C	0,0	10,0	10,0	15,0	65,0
20	30,0	30,3	27,3	22,4	28,5	27,1	E	20,0	40,0	5,0	5,0	30,0
21	30,0	40,3	42,4	35,3	40,1	37,9	A	30,0	20,0	30,0	20,0	0,0
22	-	-	-	-	-	-	**	-	-	-	-	-
23	60,0	62,4	62,2	59,8	59,5	58,2	B	10,0	60,0	0,0	25,0	5,0
24	-	-	-	-	-	-	**	-	-	-	-	-
25	-	-	-	-	-	-	**	-	-	-	-	-
26	40,0	36,9	32,1	27,0	30,8	30,5	A	40,0	0,0	60,0	0,0	0,0
27	60,0	55,9	53,0	43,2	47,3	43,1	B	5,0	60,0	0,0	20,0	15,0
28	35,0	29,7	33,6	29,2	31,4	31,2	E	0,0	5,0	5,0	55,0	35,0
29	30,0	28,6	28,9	28,4	27,4	26,0	E	15,0	30,0	10,0	15,0	30,0
30	90,0	69,0	69,7	65,1	64,8	62,9	B	5,0	90,0	0,0	0,0	5,0
31	45,0	44,8	40,8	33,6	37,3	35,2	D	0,0	0,0	15,0	45,0	40,0
32	75,0	63,4	65,2	60,0	60,0	59,3	A	75,0	15,0	0,0	10,0	0,0
33	40,0	55,9	51,8	48,6	49,4	48,4	C	15,0	0,0	40,0	40,0	5,0
34	50,0	53,8	53,4	41,7	49,8	46,6	C	5,0	20,0	50,0	20,0	5,0
35	70,0	56,9	59,4	57,1	54,8	52,5	E	0,0	0,0	15,0	15,0	70,0

Table 2: Distribution of graduates' responses, in percentages per alternative, in the objective questions of the CE, in comparison with other broader results

Source: available at https://enade.inep.gov.br/enade/#!/relatorioCursos

It appears that the UO presented a result lower than the national average in only 5 items (13.16, 19, 21, 33), having surpassed this reference value in the others. Although these items can be taken as a focus for analyzing difficulties, it is understood that the study of distractors proposed here broadens the study of weaknesses, by also incorporating questions with above-average results.

In table 3 it is observed that 4 items (9, 22, 24, 25) were disregarded in the calculation of the ENADE concept, due to the weak discrimination index (Bisserial Point) of less than 20%. Furthermore, the columns administrative category (public/private) and academic organization (college/university center/university) were considered irrelevant for the purposes of this analysis. The ease index in the 23 questions was also highlighted, in colors, namely: difficult in red (11 items – 48%), medium in yellow (10 items – 42%), easy in green (2 items – 9%).

	Hit Percentage						
Question	Curso	UF	Region	Cat. Adm.	Org. Acad.	Brazil	Template
9	-	-	-	-	-	-	**
10	60,0	35,2	35,8	29,5	33,1	32,0	D
11	50,0	52,1	54,0	46,5	48,0	44,9	D
12	55,0	48,6	51,8	47,9	47,2	44,8	D
13	20,0	32,4	30,5	25,7	27,2	25,8	A
14	65,0	50,3	50,7	40,0	49,6	46,4	B
15	45,0	36,2	37,1	31,5	37,3	34,7	D
16	20,0	46,2	46,5	38,0	44,0	41,2	A
17	45,0	40,0	40,3	36,7	39,0	36,0	C
18	90,0	68,6	66,8	56,8	65,1	62,3	C
19	10,0	20,0	20,2	18,1	20,0	19,9	C
20	30,0	30,3	27,3	22,4	28,5	27,1	E
21	30,0	40,3	42,4	35,3	40,1	37,9	A
22	-	-	-	-	-	-	**
23	60,0	62,4	62,2	59,8	59,5	58,2	B
24	-	-	-	-	-	-	**
25	-	-	-	-	-	-	**
26	40,0	36,9	32,1	27,0	30,8	30,5	A
27	60,0	55,9	53,0	43,2	47,3	43,1	B
28	35,0	29,7	33,6	29,2	31,4	31,2	E
29	30,0	28,6	28,9	28,4	27,4	26,0	E
30	90,0	69,0	69,7	65,1	64,8	62,9	B
31	45,0	44,8	40,8	33,6	37,3	35,2	D
32	75,0	63,4	65,2	60,0	60,0	59,3	A
33	40,0	55,9	51,8	48,6	49,4	48,4	C
34	50,0	53,8	53,4	41,7	49,8	46,6	C
35	70,0	56,9	59,4	57,1	54,8	52,5	E

Table 3: Classification by ease index of the CE objective items

Source: Adapted by the authors, from the Course Report of the chosen OU

Regardless of how this test was thought of in terms of difficulty, it can be seen from Table 3 that this edition materialized on a national scale as having more difficult items (11 items – 48%) than easy ones (2 items – 9%), intermediated by items of medium difficulty (10 items – 42%). It is also noteworthy that no item materialized as very easy (≥ 86% correct) or very difficult (≤15% correct).

Finally, it is understood that the items of the Specific Component (10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 26, 27, 28, 29, 30 31, 32, 33, 34, 35) allow the study of the dispersion of responses between the correct alternative and the distractors. As a cut-off parameter for the study of distractors, those that attracted at least 20% of the respondents, here considered "distractor attractors", are highlighted in red. (Table 4).

Question	Template	Course response A	B	C	D	E	SI#
~~9~~	**						
10	D	0,0	0,0	10,0	60,0	30,0	0,0
11	D	25,0	10,0	10,0	50,0	5,0	0,0
12	D	20,0	10,0	15,0	55,0	0,0	0,0
13	A	20,0	35,0	25,0	20,0	0,0	0,0
14	B	10,0	65,0	5,0	20,0	0,0	0,0
15	D	5,0	20,0	5,0	45,0	20,0	5,0
16	A	20,0	5,0	55,0	5,0	15,0	0,0
17	C	40,0	0,0	45,0	0,0	15,0	0,0
~~18~~	~~C~~	~~0,0~~	~~0,0~~	~~30,0~~	~~0,0~~	~~10,0~~	~~0,0~~
19	C	0,0	10,0	10,0	15,0	65,0	0,0
20	E	20,0	40,0	5,0	5,0	30,0	0,0
21	A	30,0	20,0	30,0	20,0	0,0	0,0
~~22~~	**						
23	B	10,0	60,0	0,0	25,0	5,0	0,0
~~24~~	**						
~~25~~	**						
26	A	40,0	0,0	60,0	0,0	0,0	0,0
27	B	5,0	60,0	0,0	20,0	15,0	0,0
28	E	0,0	5,0	5,0	55,0	35,0	0,0
29	E	15,0	30,0	10,0	15,0	30,0	0,0
~~30~~	~~B~~	~~5,0~~	~~30,0~~	~~0,0~~	~~0,0~~	~~5,0~~	~~0,0~~
31	D	0,0	0,0	15,0	45,0	40,0	0,0
~~32~~	~~A~~	~~75,0~~	~~15,0~~	~~0,0~~	~~10,0~~	~~0,0~~	~~0,0~~
33	C	15,0	0,0	40,0	40,0	5,0	0,0
34	C	5,0	20,0	50,0	20,0	5,0	0,0
~~35~~	~~E~~	~~0,0~~	~~0,0~~	~~15,0~~	~~15,0~~	~~70,0~~	~~0,0~~

Table 4: Identification of distractors that attracted more than 20% of trainees

Source: Adapted by the authors, based on the Course Report of the chosen OU

It can be seen from Table 4 that 4 items (18, 30, 32, 35) did not present attracting distractors for the chosen OU. Therefore, the scope of the analysis totals 26 distractors distributed across 19 questions. Distractors are studied by question and between questions and sets of distractors are established that reflect the same weaknesses (conceptual and/or procedural). Below we exemplify what was observed in the following set of questions about basic mechanics: item 13 (distractors: B - 35%, C – 25%, D – 20%), item 16 (distractor C – 55%) and item 27 (distractor D – 20%).

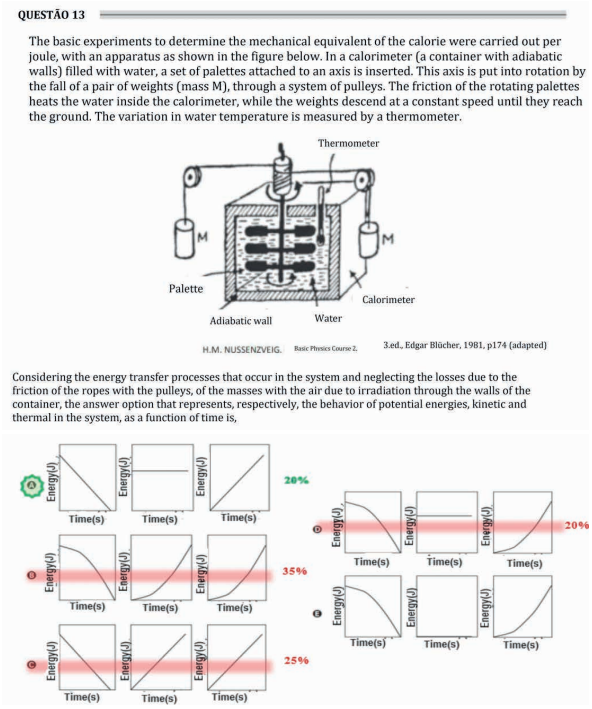
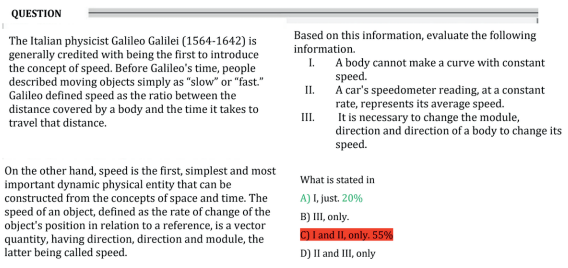


Figure 1: Question 13

Source: Adapted from ENADE 2021

The question requires thinking over time about what happens to potential, kinetic and thermal energy. As the speed is constant, the kinetic energy does not change. This means that the students attracted to distractors B and C did not perceive this relationship between the constant speed, determining the kinetic energy that was also constant. Furthermore, as friction losses are ignored, the linear reduction in potential energy causes a linear increase in thermal energy. This means that students attracted to distractor D did not recognize the linear reduction in potential energy (proportional to height) and, consequently, due to conservation, the linear increase in thermal energy.



QUESTION

The Italian physicist Galileo Galilei (1564-1642) is generally credited with being the first to introduce the concept of speed. Before Galileo's time, people described moving objects simply as "slow" or "fast." Galileo defined speed as the ratio between the distance covered by a body and the time it takes to travel that distance.

On the other hand, speed is the first, simplest and most important dynamic physical entity that can be constructed from the concepts of space and time. The speed of an object, defined as the rate of change of the object's position in relation to a reference, is a vector quantity, having direction, direction and module, the latter being called speed.

Based on this information, evaluate the following information.

I. A body cannot make a curve with constant speed.
II. A car's speedometer reading, at a constant rate, represents its average speed.
III. It is necessary to change the module, direction and direction of a body to change its speed.

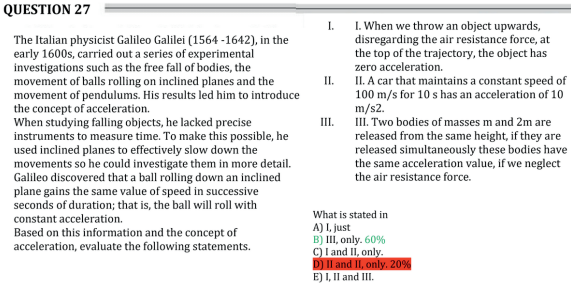
What is stated in

A) I, just. 20%
B) III, only.
C) I and II, only. 55%
D) II and III, only

Figure 2: Question 16

Source: Adapted from ENADE 2021

Here we are dealing with the vector concept of velocity correctly used in statement I and incorrectly in statement III. Neither of these two statements caused any difficulty in understanding. However, in statement II, there is a weakness in understanding the concepts of average and instantaneous speed. The statement is wrong, as it is the instantaneous speed and not the average, which ended up causing distractor C to attract 55% of respondents, considering statements I and II as correct.



QUESTION 27

The Italian physicist Galileo Galilei (1564 -1642), in the early 1600s, carried out a series of experimental investigations such as the free fall of bodies, the movement of balls rolling on inclined planes and the movement of pendulums. His results led him to introduce the concept of acceleration.
When studying falling objects, he lacked precise instruments to measure time. To make this possible, he used inclined planes to effectively slow down the movements so he could investigate them in more detail. Galileo discovered that a ball rolling down an inclined plane gains the same value of speed in successive seconds of duration; that is, the ball will roll with constant acceleration.
Based on this information and the concept of acceleration, evaluate the following statements.

I. I. When we throw an object upwards, disregarding the air resistance force, at the top of the trajectory, the object has zero acceleration.
II. II. A car that maintains a constant speed of 100 m/s for 10 s has an acceleration of 10 m/s2.
III. III. Two bodies of masses m and 2m are released from the same height, if they are released simultaneously these bodies have the same acceleration value, if we neglect the air resistance force.

What is stated in
A) I, just
B) III, only. 60%
C) I and II, only.
D) II and II, only. 20%
E) I, II and III.

Image 3: Question 27

Source: Adapted from ENADE 2021

The experiment deals with the concepts of speed and acceleration. Statement I is incorrect, as acceleration (due to gravity) acts all the time. The same reasoning makes statement III correct. Statement II is incorrect, as a car with constant speed (in straight-line motion) has zero acceleration. The intuitive (and mistaken) application in this context of the relationship between speed/time made alternative D a distractor that attracted 20% of respondents.

The 5 distractors of these 3 items evoke weakness in the understanding of Basic Mechanics, specifically kinematics and energy. Other distractor attractors that could be aggregated into at least two items deal with Practice in Teaching Physics in Basic Education (item 10, distractor E – 30% and item 19, distractor E – 65%) and about Inclusion (item 31, distractor E – 40% and item 33, distractor D – 40%). The remaining distractors could not be added and may represent isolated points of difficulty.

It is understood that the weaknesses consolidated in several distractors can subsidize, albeit in a complementary way, the curricular matrix of the UO under study, particularly in the syllabi and methodology for implementing the teaching plans of related curricular units.

FINAL CONSIDERATIONS

We sought to describe an analysis methodology, based on ENADE assumptions, a large-scale exam that uses classic test statistics, which presupposes the use of ease and discrimination indicators for each item. The performance of each observation unit is presented in public reports and the sequencing of course performance analysis was exemplified for an observation unit (OU) of a Physics degree at ENADE 2021.

The attraction (≥ 20%) exerted on graduates of this Observation Unit (OU) by distractors of objective questions of the specific component was investigated. The percentage distribution of responses from graduates of this OU across the item alternatives allowed us to infer weaknesses in content (conceptual or procedural), highlighting those observed in at least two questions. In this scope, weaknesses linked to the content of Basic Mechanics, Practice in Teaching Physics in Basic Education and Inclusion were found in

the UO studied.

It is understood that the systematic analysis now proposed is based on the understanding that such weaknesses (conceptual and/or procedural) can support the use of ENADE, in addition to its summative character, and can contribute to curricular changes, in a timely manner. review of Pedagogical Projects, according to the new DCN for teacher training.

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