Aligning evaluation with achievement objectives: Automated exams based on Bloom's taxonomy

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The question

- How many of social sciences students passing introductory statistics courses develop the expected skills to make a meaningful use of statistics?

The context

Our location

- National University of Córdoba (Argentine)
- Psychology degree
- Psychostatistics: annual introductory course with 1500 students from diverse social and educational background

Psychostatistics relates to nodal subjects in Psychology degree

Related subjects

- Psychometric Techniques
- Research Methodology
- Educational Psychology
- Health psychology
- Neuro & psycho physiology
- Social Psychology

Its objectives are in correspondence with the four pillars of learning for the 21st century (UNESCO)

Learning to...

- know (conceptual) Concepts & techniques for organization, summary and treatment of data
- do (procedural) Apply statistical tools to Psychology research problems
- be (attitudinal) Develop critical judgment, creativity & statistical thinking live together
- know and work with others (social) team working is encouraged to resolve activities

The problem

The problem

- Every year, approximately 80% pass this course.
- But the exams can be approved with little or no accomplishments of these objectives.

Many students:

- The next year they are unable to handle the tools required to perform psychometric analysis.
- Two years later they cannot compare two experimental groups.

Why?

- Literature suggests that Psychology is often chosen by students with less interest and more negative self-assessments in mathematics, physics, etc.
- Frustrating experiences that students may have had in mathematics make them feel unable to catch statistics ideas.

Why?

- For many students there is a barrier prior to the attempt to understand, founded in the scarce self-confidence to learn contents that evoke mathematics: lack of self-efficacy for quantitative reasoning.

Why?

- The idea of an innate inability for mathematics radiates towards statistics.
- It limits the time and effort the student devotes to trying to understand.

Students' strategies

How do they manage to pass?

- Given the need to pass the exams, the students look for shortcuts to overcome the obstacles in the shortest time and with the least effort.
- Many of them try to learn what is necessary to pass, and the easiest way to do so is by memorization based on repetition.

As a result

- A high proportion of students pass the course but...
  - No meaningful
  - Nor lasting

learning is achieved.

Our strategies

Firsts attempts

- Friendly bibliography.
- Proximity to data from begining.
- Low difficulty in the first examination.

In run: Creation of a well-targeted exam that

- Is aimed to the course objectives.
- Turns very inconvenient rote studying.
- Allows the identification of problematic content.

By means of:

- Fragmenting the contents of the syllabus into elementary units.
- Identifying, in each micro-content, each of Bloom's cognitive levels (knowledge, understanding, application, analysis, synthesis and evaluation).

By means of:

- Precisely designing a question for each combination of micro-content and cognitive level.
- Diversifying the questions through random values generation.

Example

Item XXXX

"With a confidence of (1-α), we estimate the mean reaction time to a stimulus in $[L_L; U_L]$. If the confidence changes to (1-α_1), keeping everything else fixed, which of the following intervals could correspond to the estimation of the same parameter".

This item points at:

- Evaluated micro-content: *effect of confidence in estimation error*
- Cognitive level: *analysis*

Diversification

Multiply the number of items

- The structure is reproduced with random values of α, α_1, L_L and U_L
- Using the **R** (R Team Core, 2018) package **exams** (Zeileis, Umlauf, & Leisch, 2014), in **markdown** (Allaire, Horner, Marti & Porte, 2017) environment.
- Questions are then exported to Moodle.
- For each student, Moodle picks randomly a set of n questions from the categories previously established, with shuffled answer options.

See:

https://github.com/mentoldo/exam_stat/tree/development for implementation

Difficulty level

Moodle provides Facility Index, i.e. the proportion of times the question was correctly answered; it serves to:

- Monitor and adjust questions to improve its quality.
- Determine which contents bring more difficulties to students.

Example

Data generation

```
## data:
b0=round(runif(1,min=.2, max=.9),2)
b1=round(runif(1, min=1.9, max=2.9),2)
```

Question

The reaction time to a visual stimulus (in seconds) is modeled as a function of alcohol blood concentration (in grams). The resulting model is: y = 0.47+1.9*x.
According to this model, when alcohol concentration increases one gram, we estimate that the mean reaction time:

Answerlist

- Increases in 1.9 seconds
- Decreases en 1.9 seconds
- Increases en 0.47 seconds
- Decreases en 0.47 seconds
- Keeps unchanged
- It depends on correlation coefficient´s value

Solution

Answerlist

- TRUE
- FALSE
- FALSE
- FALSE
- FALSE
- FALSE

In brief

Here we are trying to combine:

- A detailed thematic classification of the contents of the subject, which identifies elementary units.
- Their distribution according to the cognitive level to which they refer, following Blooms taxonomy.

With

- The production of a large number of evaluation items that inquire about the same content, with variations in the numerical values and in the response alternatives.

And

- The empirical analysis of the difficulty that each question generates in the students. This helps us to keep track of the themes that appear harder to learn for them and gives us hints to continuously improve the classes as well as the exams.

Our expectations

to produce:

- Targeted
- Personalized
- Unpredictable

exams

Our expectations

and this way:

- Dicourage rote learning
- Encourage understanding
- Promote meaningful learning

Thank you very much for your interest.

Questions and suggestions are welcome.