Formative Assessment & (Dispositional) Learning Analytics

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Aim

Connecting:

- **Computer Assisted Formative Assessment** & Practicing in the domain of mathematics
- **Learning Analytics** based on track data generated by e-tutorial systems
- **Learning dispositions** approach proposed by Buckingham Shum & Deakin Crick (LAK2012) as a framework for learning analytics applications that integrate track data with ‘intentional data’ based on self-report instruments,

...to generate learning feedback
Educational context


Local (Maastricht): do so for a large, very international and very heterogeneous population of business & economics 1st year students.

Data: ‘16/’17 cohort, 1093 students, 82% international.
Learning context

Blended/technology enhanced learning, flipped-classroom

- Face-to-face component: PBL, problem-based learning tutorials, in small tutorial groups, student-centered, 2nd year students as tutor (75 TGs, 14 students)


Homework: Week 6, Chapters 10 & 11: Testing Hypotheses about

Score: 0 of 1 pt

11.1.29

A sample of 20 CEOs shows total annual compensations ranging from a minimum of $0.1 to $64.11 million. The average for these 20 CEOs is $17,421 million.

The histogram and boxplot are shown above. Based on these data, a computer program found that a 95% confidence interval for CEOs is (-6.43, 41.28) $M. Why should you be hesitant to trust this confidence interval?

Choose the correct answer below.

- A. The assumptions and conditions for a t-interval are not met. The distribution is bimodal.
- B. The assumptions and conditions for a t-interval are not met. The distribution is too skewed for a sample size of only 20.
- C. The assumptions and conditions for a t-interval are not met. The distribution has a large outlier that is pulling the mean higher.
- D. The assumptions and conditions for a t-interval are met. The confidence interval is satisfactory.
MyLab Homework & Test manager

- Assignments are of Homework, Quiz or Test type
- Assignments can be time restricted, or conditional upon mastery
MyLab Homework & Test manager

Items for homework/quizzes/tests can be selected from section **item banks**, specific for the textbook.
MyLab Gradebook functions

Gradebook provides:

• Reports by assignment type (homework, quizzes, tests)
• Reports on individual students (both mastery and performance)
• Reports of class mastery per lesson
MyLab Review function

- Reviews of student solutions are available in homework mode, quiz mode and test mode
- Reviews are available to both students themselves, and teachers
MyLab Data export

Excel downloads are standard available of:

- Performance data (quizzes and tests)
- Mastery data (homework)
- Time on task
- Number of attempts per task

Non-standard downloads:
Type of feedback issued by any student (Help me solve this versus View an example)
Learning feedback

ML system provides different types of learning feedback (Narciss)

- Help Me Solve This for help to solve the problem step-by-step (Knowledge of Result/response, KR type feedback)
- View an Example to ask for a fully worked example (Knowledge of the Correct Response, KCR type feedback)
- Check Answer, Multiple-Try type feedback
Learning aids

- Focus in research: what students make use of what learning aids?

- Learning aids in SOWISO:
  - Solve and check
  - Ask theory
  - Ask solution
  - Ask hint
Hints in SOWISO

• Hints are context dependent: the stage of solving the exercise determines the hint

💡 Hint
The contour graph is given by the equation \( f(x, y) = f(a, b) \).

\[
f(a, b) = __
\]
Theory in SOWISO

• Theory pages provide a short theoretical summary of the solution steps

Theory Visualizing bivariate functions

Bivariate functions can be visualized in different ways; the most notable uses the concept of a graph. We recall that the graph of a function $f$ of a single variable is the set of points $[x, y]$ with $y = f(x)$ and that the graph of a function $f$ of two variables is the set of points $[x, y, z]$ with $z = f(x, y)$. Usually, the graph is a surface in 3-dimensional space. Here are a few notions that help to gain visual insight into the graph.

Level curves et al.

Let $f(x, y)$ be a bivariate function.

• The level curve of $f(x, y)$ at level $c$ is the set of points $[x, y, c]$ with $f(x, y) = c$.
• The projection on the $x, y$-plane of a level curve at level $c$ is called a contour graph at level $c$. The contour graph at level $c$ is the set of all $[x, y]$ in the domain of $f$ such that $[x, y] = c$ for a fixed value $c$.
• A curve of the form $[a, y, f(a, y)]$ for a fixed value $a$ or of the form $[x, b, f(x, b)]$ for a fixed value $b$ is called a coordinate curve of $f$. Some of these methods are illustrated in the examples below.
Solution in SOWISO

• The solution page provides a full solution, allows learning by example.

♀ Hint
The contour graph is given by the equation \( f(x, y) = f(a, b) \).

\[ f(a, b) = e^{-1} \]

In general, a level curve is given by the equation \( f(x, y) = z \) for a particular value of \( z \). Here, that value is \( f(a, b) \). Thus, the equation of the level curve is

\[ e^{-x^2-y^2} = e^{-a^2-b^2}, \]

which can be rewritten as

\[ x^2 + y^2 = a^2 + b^2 \]

because the function \( \exp(-x) = e^{-x} \) is injective.

This curve is a circle of radius \( \sqrt{a^2 + b^2} \) if \( a^2 + b^2 > 0 \) and a point if \( a^2 + b^2 = 0 \). (Observe that we always have \( a^2 + b^2 \geq 0 \).) As the curve is given to be the unit circle, we conclude that \( a^2 + b^2 = 1 \), so

\[ f(a, b) = e^{-a^2-b^2} = e^{-1}. \]
First aim: predictive modelling, signalling students at risk

Being in a ‘data rich’ learning environment, our goal is to investigate the power of several data types, and especially LMS (BB) and formative assessment data, in predictive modelling.

Data available:

- BlackBoard data, click and time-on-task
- MyLab track data: mastery data, time-on-task data, attempts data
- Learning dispositions (learning styles, goals, motivation, engagement, expectancy-value data, self-theories of intelligence, effort beliefs, ...)
- Prior education, diagnostic prior knowledge tests
- Formative assessments (quizzes) performance data
- Final exam
Longitudinal aspects of systems data in predicting performance:

- Week0: diagnostics entry tests for mathematics and statistics, with a strong focus on basic algebraic skills, a well-known topic for high school deficiencies.
- Week1: mastery scores and practice time in MyMathLab and MyStatLab.
- Week2: mastery scores and practice time in MyMathLab and MyStatLab.
- Week3: mastery scores and practice time in MyMathLab and MyStatLab, and Quiz1 scores for mathematics and statistics.
- Week4: mastery score and practice time in MyMathLab and MyStatLab.
- Week5: mastery scores and practice time in MyMathLab and MyStatLab, and Quiz2 scores for mathematics and statistics.
- Week6: mastery score and practice time in MyMathLab and MyStatLab.
- Week7: mastery scores and practice time in MyMathLab and MyStatLab, and Quiz3 scores for mathematics and statistics.

All weeks: BlackBoard intensity of use data, both clicks and connect time, both aggregated, and disaggregated for BB functions or BB items.
Investigating predictive power

Building our prediction equations in steps:

1. BlackBoard track data
2. MyLab track data
Investigating predictive power

3. Cognitive data: diagnostic entry tests & formative assessments

MML & MSL track data

Entry & formative assessment data
Investigating predictive power

4. All data (including dispositions)

Conclusions: data from formative assessments dominate all other data in predictive power. However: not available before half way the course. For early interventions, a 2nd best is the combination of:

Diagnostic prior knowledge test, prior education, learning dispositions, and MyLab track data.
Timely & predictive feedback

• If one can wait till halfway the course (end Week3 our example), (semi-) formative assessment data provide quite accurate feedback
Second aim: clustering

- Can we distinguish different types of learners on the basis of the learning behaviours in the digital tools only: how intensive they use the tool, what preferences for learnings aids
- How do these type relate to learning dispositions?
Clusters of time on task intensity, and performance

- If we clusters students in 5 groups, based on time on task, or time on task per attempt, and compare clusters on performance, we find a very different relationship.

- Positive correlation is result of different behaviour in very low time group. In other groups: negative relationship, especially for exam performance, or absence of relationship (quiz performance).
Learning disposition surveys

- Epistemological self-theories of intelligence (Dweck)
- Epistemological views on role effort in learning (Dweck, Blackwell)
- Epistemic learning emotions (Pekrun)
- Cognitive learning processing strategies (Vermunt)
- Metacognitive learning regulation strategies (Vermunt)
- Subject (math & stats) attitudes (Schau)
- Academic motivations (Deci & Ryan)
- Achievement goals (Elliott)
- Achievement orientations (Dweck & Grant)
- Learning activity emotions (Pekrun)
- Motivation & Engagement wheel (Martin)
- Cultural intelligence (SFCQ)
- Help seeking behaviour
Example: Martin’s ‘Motivation & Engagement Wheel’

Four quadrants based on:

- Thoughts (Cognitions) ⇔ Behaviours
- Adaptive ⇔ MalAdaptive
Feedback reporting

In the experiment, feedback was organized:

• System track data: continuous feedback to students, weekly overviews to tutors
• Dispositional data: to students after due date, in absolute and relative format, using ‘simple’ graphical tools

Limitations: Feedback for separate data sources, not integrated
Cluster analysis on trace data including feedback use

- Cluster analysis suggests 6 learner profiles
- Largest cluster differences: #Attempts and #Solutions
demographics

- Largest differences in prior math education, smaller gender effect
- National culture: masculinity and long-term orientation
Next question: what role do national culture dimensions have in the design of prediction models

Hofstede national culture dimensions:

- Power Distance Index (PDI)
- Individualism versus Collectivism (IDV)
- Masculinity versus Femininity (MAS)
- Uncertainty Avoidance Index (UAI)
- Long Term Orientation versus Short Term Normative Orientation (LTO)
- Indulgence versus Restraint (IND)
Masculinity versus Femininity cultural dimension

Large European differences

Masculinity:
- education is characterized by competition, openly striving for excellence, taking the best students as the norm, and regarding failure as a disaster.
- In contrast, in “feminine” countries, the average student is the norm, and excellence is something one keeps to oneself.
Large European differences

• **Uncertainty Avoidance**

  Students from strong uncertainty-avoidance countries, prefer structured learning situations with precise objectives, detailed assignments, and teachers in the role of experts.

• As opposed to weak uncertainty-avoidance countries, where the teacher may say ‘I do not know’, and learning situations tend to be open-ended.
Metacognitive regulation and cognitive processing

- Vermunt’s ILS, first two domains
- Differences in self-regulation
- Differences in both deep and step-wise learning strategies
Epistemic and achievement emotions

- Pekrun’s framework
- Achievement emotions: Boredom and Hopelessness
- Epistemic emotions: Confusion, Anxiety, Frustration
• Martin’s motivation & engagement wheel:
  – Adaptive behaviours: planning, persistence
  – Maladaptive behaviours: Self-sabotage, disengagement (& uncertain control)
• Same patterns visible in student performance: exam and quizzes (mid-term tests)
Conclusions

• LA applications have much potential in terms of predictive modeling: what students are at risk of failing the course, or even dropping out?

• LA feedback is however not always ‘actionable’: knowing that a student is not very active in using a learning tool, it does not help much to tell.

• DLA or Dispositional LA can add that dimension of ‘actionable data’ by connecting suboptimal performance to learning dispositions. It is the first step to a concrete educational intervention.