Chapter 8:
Measuring learning effects
Research Question

Is it more effective to watch MOOCs individually or in teams?
Independent Variable: Solo / Team
Dependent Variable: Test Score
Experimental Plan: Between Subjects, 1 dimension

<table>
<thead>
<tr>
<th>Factor</th>
<th>Modality 1</th>
<th>Modality 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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- Independent variable
- Condition
- Experimental Group
- Control Group
Research Sub-Question

Is it more effective to watch MOOCs individually or in small teams?

Research Sub Questions

- It depends on the size of the group
- It depends on the school culture
- It depends on difficulty of the video
- It depends how well the group members know each other
- It depends ...
### Experimental Plan: Between Subjects, 2 dimensions

<table>
<thead>
<tr>
<th>Factor 2</th>
<th>Modality 2.1</th>
<th>Group A</th>
<th>Group E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modality 2.2</td>
<td>Group B</td>
<td>Group D</td>
<td></td>
</tr>
<tr>
<td>Modality 2.3</td>
<td>Group C</td>
<td>Group F</td>
<td></td>
</tr>
</tbody>
</table>
Interaction Effects

The effect of one independent variable on the dependent variable depends upon the other independent variable.
Interaction Effect?
Experiment Biases

Were the groups really equivalent at the beginning?

- same age (in average) → Questionnaire
- same gender ratio → Questionnaire
- same socio-cultural level → Questionnaire
- same school level → Recruitment
- same background knowledge → Pre-test
- same level for mutual knowledge (friends?) → Recruitment
- same level of intelligence → Pre-test
- same spatial reasoning → Pre-test
Paper Folding Test

The two figures on the left represent a square piece of paper being folded. In the second figure a small circle shows where a hole has been punched through all of the thicknesses of paper. Choose the drawing on the right that shows where the holes are after the paper has been unfolded.

Moyennes d'inférence selon les capacités de rotation mentale

![Graph showing scores for Paper Folding Test]
Were the groups really equivalent at the beginning?

SOLUTIONS

Control before forming groups

- Distribute Equally among conditions: controlled variables

Control after forming groups

- Verify that the groups do not differ significantly: randomized variables

Control after forming groups

- If the groups do not differ significantly, use covariate analysis

Use “repeated measures” also called “within subjects”
Experimental Plan: *Within* Subjects, 1 dimension

<table>
<thead>
<tr>
<th>Factor</th>
<th>Modality 1</th>
<th>Modality 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Second</td>
<td>First</td>
</tr>
<tr>
<td>Second</td>
<td>First</td>
<td>First</td>
</tr>
</tbody>
</table>

The same subjects pass in both conditions

Pro: fewer subjects, samples are equivalent
Cons: complex order effects

COUNTER-BALANCING (avoiding the order effect)
Research Sub Questions

Is it more effective to watch MOOCs individually or in small teams?

2. Why are they better?
3. Why are they better?

Conditions $\rightarrow$ Processes $\rightarrow$ Effects

$Independent$ $Variables$

$Dependent$ $Variables$
3. Why are they better?

Conditions → Processes → Effects

Independent Variables

Social facilitation?
Explanation effect?
More knowledge?

Dependent Variables
3. Why are they better?

**Conditions**
- Independent Variables
  - Recorders
  - Eye trackers
  - Questionnaires (NASA TLX)

**Verbal Interactions**
- Turn Taking mechanisms
- Non-verbal interactions
- Social relationships
- Gaze Patterns
- Deictics

**Processes**
- **Process Variables**

**Dependent Variables**

**Effects**
Example: The effect of persistency of information
3. Why are they better?

Conditions → Processes → Effects

**Independent Variables**
- Persistency of information (‘vignettes’)
- Frequency of content-rich interactions

**Process Variables**
- 

**Dependent Variables**
- Score at post-test
3. Why are they better?

- Conditions → Processes → Effects

  - Independent Variables → Mediation Effect → Dependent Variables

  - Process Variables
Research Sub Questions

Is it more effective to watch MOOCs individually or in small teams?

3. Could this difference be explained by chance?
3. Could this difference be explained by chance?

Is this difference in group means due to **sampling** or is it the effects of condition changes?

If group 2 had been in condition 1 and group 1 in condition 2, would group 2 still get a higher performance?
Score

\[ m = 37.2 \]

\[ m = 38.1 \]

\[ m = 2.8 \]
The sample size reduces the probability to get by chance a sample mean that is far from the population means.
The differences of mean are the same, but which one is more significant?
“Significant” does not mean “large”!
<table>
<thead>
<tr>
<th>Variables</th>
<th>Types of Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, Gender, Row in classroom, Teacher: A or B</td>
<td>Nominal, discrete</td>
</tr>
<tr>
<td>Learning style, IQ Test, Mental Rotation test</td>
<td>Ordinal, ordered</td>
</tr>
<tr>
<td>Motivation test, Level (low, medium, high)</td>
<td>Metric, continuous, normal (?)</td>
</tr>
<tr>
<td>Opinions, Pre-test score, Post-test score</td>
<td></td>
</tr>
<tr>
<td>Learning gain, Response time</td>
<td></td>
</tr>
<tr>
<td>Balance of participation</td>
<td></td>
</tr>
<tr>
<td>Number of help requests</td>
<td></td>
</tr>
<tr>
<td>Total fixation time on X</td>
<td></td>
</tr>
<tr>
<td>Gaze paths, Sequences of actions</td>
<td></td>
</tr>
</tbody>
</table>

1. Nominal, discrete
2. Ordinal, ordered
3. Metric, continuous, normal (?)
4. Times series
Age
Gender
Row in classroom
Teacher: A or B?
Learning style
IQ Test
Mental Rotation test
Motivation test
Level (low, medium, high)
Opinions
Pre-test score
Post-test score
Learning gain
Response time
Balance of participation
Number of help requests
Total fixation time on X
Gaze paths
Sequences of actions

≠ types of variables
≠ distributions
≠ analyses

1. Nominal, discrete
2. Ordinal, ordered
3. Metric, continuous, normal (?)
4. Times series
<table>
<thead>
<tr>
<th>Categories (Discrete)</th>
<th>Ordinal (Scale)</th>
<th>Metric (Continuous)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Single Value</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ind: LearnStyle= Surface</td>
<td>Ind: Motivation= Low</td>
<td>Ind: IQ= 142</td>
</tr>
<tr>
<td>Dep: Style = Leader</td>
<td>Dep: CodeQuality= Low</td>
<td>Dep: Score= 23</td>
</tr>
<tr>
<td><strong>Time Series</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ind: {play pause back…}</td>
<td>Ind: Attention {3 3 5 …}</td>
<td>Ind: HeartRate {60 90 …}</td>
</tr>
<tr>
<td>Dep: gaze {O₁ O₃ O₁ O₂…}</td>
<td>Dep: {low low med …}</td>
<td>Dep: RespTime {33 22 10…}</td>
</tr>
<tr>
<td><strong>2D &amp; More</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gaze {(X₁ Y₂, α₁, T₁}, ….}</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ANOVA

CHI-SQUARE

KRUSKALL

ANOVA

Supervised Learning

Supervised Learning

REGRESSION
Is learning in teams more effective than learning alone?

Do students who watch the MOOC at the same time succeed better?

Solo / Team

- Designed experiment
- Test Score

VideoPlay (time, hour)

- Post-hoc Analysis
- Test Score
Correlation: 67%  Sources: CDC & IMDB  tylervigen.com
Does MOOC activity increase EPFL grades?

Table 3: Comparison of normalized grades (z-scores) for students who participated to the MOOC (yes) and students who did not participate (no).

<table>
<thead>
<tr>
<th>Course</th>
<th>t</th>
<th>df</th>
<th>p</th>
<th>MOOC(N)</th>
<th>Course (z-score)</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>yes</td>
<td>no</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.04</td>
<td>-0.54</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.04</td>
<td>-0.70</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.04</td>
<td>-0.34</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.07</td>
<td>-0.73</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.11</td>
<td>-0.20</td>
<td>0.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.05</td>
<td>-0.73</td>
<td>0.79</td>
</tr>
</tbody>
</table>
Correlation ≠ Causality
Summary

- Research Question: To be answered by the experiment
- Hypothesis: Expected results (A > B); an affirmation
- Independent variables: What one varies between the conditions (or Factor)
- Modality: Value of a factor
- Condition: Set of (factor, modality) per group of subjects
- Control group: The reference against which one will compare
- Dimension: Number of factors
- Dependent variables: How does one measure the effects?
- Controlled variables: Things you try to keep constant or to randomize
- Intermediate variables: Explain the link from Independent to Dependent Variables
- “Significant” difference: Probably (<5%) not due to sampling error
- Interaction effect: The effect of one IV on the DV depends upon another IV
- Between/Within subject: Do subjects pass in one or several conditions?
- Counterbalancing: Inverting the order of conditions for within-subject plans