Second-Order Meta-Analysis:* Effects of Technology on Students’ Achievement

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Technology and Learning

- Digital and computer technology has evolved drastically over the years

- Question of whether technology is advantageous to students’ achievement is still questionable and debatable

- A multitude of studies conducted to answer the question (achievement and attitude)
MA & Technology Integration

- Numerous meta-analyses varying in aspects including focus, scope, content, sample, and methodological quality
  - e.g. Timmerman & Kruepke, 2006; Christmann & Badgett, 2000; Bangert-Drowns, 1993; and Cohen & Dacanay, 1992

Overall Research Question

- Does technology use enhance student achievement?
Potential Approaches

- Conduct a new comprehensive MA
- Qualitative synthesis of the meta-analyses
- Quantitative synthesis of the meta-analyses

Quantitative Synthesis of MA

- Has been experimented with by different researchers but not in the educational technology field:

<table>
<thead>
<tr>
<th>Authors</th>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrick, Mount &amp; Judge</td>
<td>2001</td>
<td>Personality and performance</td>
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<tr>
<td>Lipsey and Wilson</td>
<td>1993; 2001</td>
<td>psychological, behavioral, and educational treatment</td>
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<tr>
<td>Luborsky et al.</td>
<td>2002</td>
<td>Psychotherapy &quot;Dodo bird verdict&quot;</td>
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<td>Møller and Jennions</td>
<td>2002</td>
<td>Evolutionary biology</td>
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<tr>
<td>Peterson</td>
<td>2001</td>
<td>College students and social science research</td>
</tr>
<tr>
<td>Sipe and Curlette</td>
<td>1997</td>
<td>Factors related to educational achievement</td>
</tr>
</tbody>
</table>
Second-order meta-analysis: Objectives

- Synthesize findings of the MA through a second-order MA
- Explain the variance in the effect sizes if possible
- Validating the results of the second order-MA

Research Questions

- Does technology use enhance student achievement in formal face-to-face classroom settings as compared to traditional settings? If so, to what extent?
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- Does technology use enhance student achievement in formal face-to-face classroom settings as compared to traditional settings? If so, to what extent?

- What features, if any, moderate the overall effects of technology use on students' achievement?
Effect size change over time (Schmid et al., 2009)

Methodology

1. Developing inclusion/exclusion criteria.
2. Constructing and implementing search strategies.
3. Reviewing and selecting meta-analyses.
4. Extracting effect sizes and standard errors.
5. Developing a codebook.
6. Coding study features.
7. Designing and calculating the methodological quality index.
8. Identifying unique set of meta-analyses.
9. Conducting statistical analyses.
10. Interpretation.
MA Included If:

- Addressed impact of any form of computer technology as a supplement for in-class instruction as compared to traditional in-class instruction
- Dealt with students at different levels of regular classroom settings in formal education
- Focused on the impact of the computer technology on students’ achievement or performance
- Was published during or after the year 1985
- Is publicly available
- Provided an average effect size that could be extracted

Reliability

- Independent review/coding by two researchers with calculation of inter-rater agreement (abstract review, study feature coding, effect size extraction)
- Establishing inter-rater agreement with a random sample of documents (full text review)
- Conducting random spot checks for data-entry (standard error calculation, average ES from raw ES, examination of primary studies included in MA)
Overall Set of MAs

- A total of 37 MAs were included with one having two independent effect sizes
- Included 1253 different primary-studies, with approximately 130,300 participants

Identifying Unique Set of MA*

- Compile overall set of primary studies in all MA
- For each MA the number and frequency of studies that were included in another MA was calculated
- Exclude highly overlapping MA one at a time (retain all strong MA) until a maximum frequency of 25% overlap was attained for each of the remaining MA
Unique Set of MAs

- 25 MAs having greatest coverage of overall set of primary-studies with minimal overlap while retaining the high quality MAs

- The MAs involved 1055 different primary-studies with approximately 109,700 participants (84.2% of overall number of primary studies)

Extracting ES

- Generally straight forward, provided by authors in form of Glass' Δ, Cohen's d or Hedges g

- Correlation coefficient converted to Cohen's d
Standard Error*

- Estimated sample-size standard error
- Estimated number-of-studies standard error

Developing Codebook

- Primary literature
- Already published second-order MA
- Literature, tools and standards for MA methodological quality
**Codebook**

- Study identification
- Contextual features
- Methodological features
  - Search phase
  - Review phase
  - Effect size and study feature extraction phase
  - Analysis
  - Further reporting aspects
- Effect size information

**Methodological Quality Index**

- 14 items addressing:
  - Comprehensiveness
  - Contemporariness
  - Accuracy (completeness, adequacy & transparency)
  - Reliability
  - Statistical adequacy
### Methodological Quality Index

- 1 to 5 = weak quality review
- 6 to 9 = average quality review
- 10 to 14 = strong quality review

### Analysis

- **Descriptives** (helping in the critical evaluation of the MA's - available)
- Outlier analyses and publication bias
- Calculation of average ES
- Test of homogeneity
- Moderator analyses
Synthesis of ES

Conducted through second-order MA:
- Using sample-size SE
- Using number-of-studies SE

Validated through*
- Using raw data (574 ES and sample sizes reported in included MA)

Results of ES synthesis

<table>
<thead>
<tr>
<th>K=38</th>
<th>Model</th>
<th>g+</th>
<th>SE</th>
<th>95% CI</th>
<th>Q-value</th>
<th>I²</th>
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<tr>
<td></td>
<td>Sample-size SE</td>
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<td></td>
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<td></td>
<td>Fixed</td>
<td>0.330*</td>
<td>0.006</td>
<td>0.316/0.342</td>
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<td>Raw ES</td>
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<td>0.304*</td>
<td>0.008</td>
<td>0.288/0.320</td>
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Moderator Analysis

Conducted with the sample-size SE approach:

- **Methodological quality:**
  - weak and moderate (g=0.364*) vs strong (g=0.273*)

- **Included literature:**
  - Only published (g=0.459*) vs Published and unpublished (g=0.306*)
Conclusion

- Findings with respect to the major research question
- Need for better implementation of MA procedures and reporting*
- Validation with raw ESs supports the second-order meta-analysis procedure for estimation of average ES (based on extensive body of literature rapidly and with relatively fewer resources)*
- More work is needed for explaining variance in ESs in second-order meta-analysis*