

Impact of Ignoring Nested Data Structures on Ability Estimation

Kevin O'Neil Shropshire

Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Educational Research and Evaluation

Yasuo Miyazaki, Chair
Leanna L. House
Tina Savla
Kusum Singh
Gary E. Skaggs

May 9, 2014
Blacksburg, Virginia

Keywords: Complex survey designs, clustering, PSU, nested data, multilevel data, hierarchical data, two-level HGLM, three-level HGLM, Rasch, ability estimation.

MEMORANDUM

DATE: May 14, 2014
TO: Yasuo Miyazaki, Kevin O'Neil Shropshire
FROM: Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)
PROTOCOL TITLE: Impact of Ignoring Nested Data Structures on Ability Estimation
IRB NUMBER: 14-560

Effective May 14, 2014, the Virginia Tech Institutional Review Board (IRB) Chair, David M Moore, approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: **Exempt, under 45 CFR 46.110 category(ies) 4**
Protocol Approval Date: **May 14, 2014**
Protocol Expiration Date: **N/A**
Continuing Review Due Date*: **N/A**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

Note: complete this application only if this research project ***only*** involves the collection or study of **existing data**. Once complete, upload this form as a Word document to the IRB Protocol Management System: <https://secure.research.vt.edu/irb>

1. DO ANY OF THE INVESTIGATORS OF THIS PROJECT HAVE A REPORTABLE CONFLICT OF INTEREST? <http://irb.tedupadesresearch.com/irb>

- No**
 Yes, explain:

2. WILL THIS RESEARCH INVOLVE COLLABORATION WITH ANOTHER INSTITUTION?

- No, go to question 3**
 Yes, answer questions within table

IF YES

Provide the name of the institution [for institutions located overseas, please also provide name of country]:
Indicate the status of this research project with the other institution's IRB: <input type="checkbox"/> Pending approval <input type="checkbox"/> Approved <input type="checkbox"/> Other institution does not have a human subject protections review board <input type="checkbox"/> Other, explain:
Will the collaborating institution(s) be engaged in the research? (http://soprpoic.enae.com) <input type="checkbox"/> No <input type="checkbox"/> es
Will Virginia Tech's IRB review all human subject research activities involved with this project? <input type="checkbox"/> No, provide the name of the primary institution: <input type="checkbox"/> Yes <i>Note: primary institution = primary recipient of the grant or main coordinating center</i>

3. IS THIS RESEARCH FUNDED?

- No, go to question 4**
 Yes, answer questions within table

IF YES

Provide the name of the sponsor [if NIH, specify department]:
Is this project receiving federal funds? <input type="checkbox"/> No <input type="checkbox"/> Yes

If yes,

Does the grant application, OSP proposal, or “statement of work” related to this project include activities involving human subjects that are not covered within this IRB application?

- No, all human subject activities are covered in this IRB application
- Yes, however these activities will be covered in future VT IRB applications, these activities include:
- Yes, however these activities have been covered in past VT IRB applications, the IRB number(s) are as follows:
- Yes, however these activities have been or will be reviewed by another institution’s IRB, the name of this institution is as follows:
- Other, explain:

Is Virginia Tech the primary awardee or the coordinating center of this grant?

- No, provide the name of the primary institution:
- Yes

4. DOES THIS STUDY INVOLVE CONFIDENTIAL OR PROPRIETARY INFORMATION (OTHER THAN HUMAN SUBJECT CONFIDENTIAL INFORMATION), OR INFORMATION RESTRICTED FOR NATIONAL SECURITY OR OTHER REASONS BY A U.S. GOVERNMENT AGENCY?

For example – government / industry proprietary or confidential trade secret information

- No
- Yes, describe: **Study ID number assigned to students in CivEd data collected by IEA in 1999.**

5. DOES THIS STUDY INVOLVE SHIPPING ANY TANGIBLE ITEM, BIOLOGICAL OR SELECT AGENT OUTSIDE THE U.S.?

- No
- Yes

6. DESCRIBE THE BACKGROUND, PURPOSE, AND ANTICIPATED FINDINGS OF THIS STUDY:

In educational testing/assessment, item response theory (IRT) models are a common technique to estimate student ability/proficiency in a given subject. The IRT model assumes that students are observed independently. However, most large scale educational assessments such as NAEP, TIMSS, and PISA use complex survey designs which involve multilevel data structures such as students nested within schools. In such cases, it is very likely that students’ responses are not independent, which violates the key assumption of the IRT model. Nevertheless, IRT models continue to be used to estimate student proficiency in practice. We have limited knowledge of what would be the consequences of ignoring the nested data structure when the IRT model is applied because the research to address this question is lacking. Therefore, this study focuses on this issue by using a hierarchical generalized linear model (HGLM) for binary outcomes as the one-parameter IRT/Rasch model. This formulation allows for the model to also account for data clustering and compare the results with and without taking this design structure into consideration.

The purpose of the study was to examine two major research questions. First, what impacts does design based clustering have with respect to desirable statistical properties when estimating subject ability with the one-parameter IRT / Rasch model? Second, since the residuals from the one-parameter IRT/Rasch model have shrinkage properties, what impacts does clustering of first-stage sampling units have on measurement validity—does the first-stage sampling unit impact the ability estimate, and if so, is this desirable and equitable? In order to address these questions we want to first examine both a two-level (incorrect model) and three-level (correct model) HGLM model fit to simulated correlated item response data to determine student ability (e.g. achievement). To supplement the findings a real world assessment data example using the CivEd data would be fit with the same models.

The anticipated findings are that the three-level model will fit the data better with respect to ideal statistical properties such as bias and mean-square-error (addressing research question one). Also, it is anticipated that the three-level model will not preserve rank ordering of true subject ability to the extent of the two-level model (addressing research question two). The example data is used for providing an illustrative example for the results of the simulation study, (e.g. how the phenomena expected from the simulation results may appear in the real world data). The substantive meanings of the results of the CivEd data analysis will be of secondary interest.

7. EXPLAIN WHAT THE RESEARCH TEAM PLANS TO DO WITH THE STUDY RESULTS:

For example - publish or use for dissertation

The research team plans to use the item response data from the CivEd study to measure student ability with a two-level and three-level HGLM model. The study results would be used as an illustrative example to enhance the simulation findings in my dissertation and potentially for future publication. Since we are examining subject ability it would be ideal to sample a handful of observations from the public file to see how subject ability and confidence interval coverage compares for both models. Any public presentation of such individual findings would require the use of a pseudonym (e.g. observation A, B, etc.). In addition, it is anticipated that a majority of the results would be presented in aggregated form (e.g. sample statistics or a plot of all student abilities with each model) not requiring the use of any identifying information.

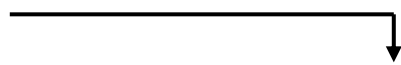
8. WILL PERSONALLY IDENTIFYING STUDY RESULTS OR DATA BE RELEASED TO ANYONE OUTSIDE OF THE RESEARCH TEAM?

For example – to the funding agency or outside data analyst, or participants identified in publications with individual consent

- No
- Yes, to whom will identifying data be released? **Note: nothing beyond what is publically available.**

9. WILL ANY STUDY FILES CONTAIN PARTICIPANT IDENTIFYING INFORMATION (E.G., NAME, CONTACT INFORMATION, VIDEO/AUDIO RECORDINGS)?

- No, go to question 10
- Yes, answer questions within table



IF YES
Describe if/how the study will utilize study codes: Data file already contains study codes for schools and subjects but does not directly identify the identity of the student or school.
If applicable, where will the key [i.e., linked code and identifying information document (for instance, John Doe = study ID 001)] be stored and who will have access? This would be applicable to the file creator. I do not have access to the link between identification or the participating subject. The International Association for the Evaluation of Educational Achievement (IEA) conducted the study in 1999 (http://www.iea.nl/) and would be source for the key.
<i>Note: the key should be stored separately from subjects' completed data documents and accessibility should be limited.</i>

10. WHERE WILL DATA BE STORED?

Data is publicly available. Downloaded data will be stored on personal laptop. No attempt will be made to merge the data or collect anything beyond what is provided by the IEA.

11. WHO WILL HAVE ACCESS TO STUDY DATA?

Public access is given at IEA website and appears available at the ICPSR website through the University of Michigan.

12. DESCRIBE THE PLANS FOR RETAINING OR DESTROYING THE STUDY DATA:

None as described-the data is available to the public

13. FROM WHERE DOES THE EXISTING DATA ORIGINATE?

(1) Public access is given at IEA website (<http://www.iea.nl/>) under Data --> "IEA Study Data Repository" --> "Search" --> CivEd
(2) Public access appears also be given at ICPSR website (see <http://www.icpsr.umich.edu/icpsrweb/ICPSR/studies/21661?q=cived&searchSource=revise>)

14. PROVIDE A DETAILED DESCRIPTION OF THE EXISTING DATA:

The standard population that was assessed in the 1999 administration consisted of approximately 90,000 14 year-old students (8th or 9th grade depending on the school system of the nation) from 28 countries. Test items measuring civic knowledge from the standard population were created through the use of two subscales—civic content knowledge and skills in interpreting political communication. The main assessment was designed to last approximately two hours and consisted of 38 multiple choice cognitive items, 17 background items, and Likert scale responses (6-25 items) measuring attitudes toward civic education across 14 civic education topics. The data to be used for this illustration is the sample selected from the United States. In this data there are 124 schools (first-stage) and 127 classrooms (second-stage) units selected. The data needed for the illustration is the subject study code, school study code, and item responses for the 38 cognitive items. There are 2,811 eligible students total in the sample.

15. IS THE SOURCE OF THE DATA PUBLIC?

- No, go to question 16
- Yes, you are finished with this application

16. WILL ANY INDIVIDUAL ASSOCIATED WITH THIS PROJECT (INTERNAL OR EXTERNAL) HAVE ACCESS TO OR BE PROVIDED WITH EXISTING DATA CONTAINING INFORMATION WHICH WOULD ENABLE THE IDENTIFICATION OF SUBJECTS:

- **Directly** (e.g., by name, phone number, address, email address, social security number, student ID number), or
- **Indirectly through study codes** even if the researcher or research team does not have access to the master list linking study codes to identifiable information such as name, student ID number, etc

or

- **Indirectly through the use of information that could reasonably be used in combination to identify an individual** (e.g., demographics)

- No, collected/analyzed data will be completely de-identified
- Yes,

If yes,

Research will not qualify for exempt review; therefore, if feasible, written consent must be obtained from individuals whose data will be collected / analyzed, unless this requirement is waived by the IRB.

Will written/signed or verbal consent be obtained from participants prior to the analysis of collected data?
-select one-

This research protocol represents a contract between all research personnel associated with the project, the University, and federal government; therefore, must be followed accordingly and kept current.

Proposed modifications must be approved by the IRB prior to implementation except where necessary to eliminate apparent immediate hazards to the human subjects.

Do not begin human subjects activities until you receive an IRB approval letter via email.

It is the Principal Investigator's responsibility to ensure all members of the research team who collect or handle human subjects data have completed human subjects protection training prior to handling or collecting the data.

-----END-----