# Project outline for computational assessment

**Danny Caballero**[1,2]

[1]Michigan State University
[2]University of Oslo

April 1, 2017

## Assessing Computational Understanding in Physics

### Rationale

- Systematic measurement of student understanding is essential for evaluating movement towards more computational instruction
- Partners (i.e., PICUP and faculty collaborators) are grokking for some form of systematic assessment in specific classes
- Assessments can help drive further research investigations including comparative and longitudinal studies
- The development of these assessments can lead to high visibility of the centre

## Assessing Computational Understanding in Physics

### Product

- A suite of assessments of computational understanding in physics that are:
  - developed for specific courses, yet broadly applicable,
  - informed by observed student understanding,
  - grounded in faculty-articulated learning goals,
  - developed using strong theoretical grounding and methodology, and
  - deployed in a centralized way to facilitate community-level research.

## Principles of Development

- Course-specific
- Broad applicability
- Informative about student understanding
- Informative to and valuable for faculty
- Strong theoretical basis for design and measurement

## Principles of Development

**Course-specific**

- Goals for including computation and thus assessments are tied to specific learning outcomes for courses
- Course content is one such aspect, but others include the expectation of more advanced and deeper understandings of the same algorithms and tools
- As different courses vary in their depth and focus, overlapping course content should be evaluated (lowest-common denominator assessment)

## Principles of Development

**Broad applicability**

- Assessments developed for specific courses should emphasize common content and topics (i.e., overlapping learning goals)
- Broader applicability of the assessments will lead to broader use of the assessments
- Can support developing a wealth of understanding about implementation and demographic effects

## Principles of Development

**Informative about student understandings**

- Assessments should provide information beyond the percentage of students answering correctly
- Selected assessment stems should provide information about what understandings students are holding in the moment
- Stems should be drawn from expressed understandings of students
- Validation of the assessments must include discussion with students

## Principles of Development

### Informative to and valuable for faculty

- As such assessments are meant to inform faculty about changes made to their won courses, these assessment development must involve faculty
- Learning outcomes that will be evaluated must be drawn from faculty teaching specific courses
- Validation of the assessments must include discussion with faculty
- Centralized deployment and analysis can ensure minimal impact on faculty time

## Principles of Development

### Theoretical and Methodological Grounding

- Interviews with students and faculty will explore the variation in understanding and faculty learning goals (Phenomenographic and conceptual approach)
- Continuous validation of items against student understanding and faculty learning goals as assessments are constructed
- Assessment design will make use of appropriate measurement theory (Rasch model)

## Project Details

### Key Project Elements

For a given assessment, we will:

- Interview faculty about their goals for teaching computation and from what experiences those goals are derived (**Faculty Goal Interviews**)
- Interview students about their computational understandings (**Student Understanding Interviews**)
- Develop a preliminary assessment of student understanding informed by faculty goals and categories of student understanding (**Assessment Construction**)
- Validate the assessment through discussion with faculty, interviews with students, and the use of Rasch modeling on specific items (**Validation Interiews** and **Rasch Analysis**)
- Deploy the assessment in relevant contexts (**Evaluation and Further Studies**)

## Project Details

### Faculty Goal Interviews

- Interview faculty about their computational experiences and how those experiences lead them to think about what students should "get out of" their computational experiences in a specific class
- Develop the outcome space for these interviews, which is likely to include computational learning goals
- Categories of faculty computational experiences and how those relate to what their students should learn is the overarching research
- Computational learning goals derived from these interviews help form the basis for assessment development

### Possible Papers

- AJP article - faculty learning goals for computation
- PR-PER article - phenomenongraphic study of faculty computational experiences and their relation to computational learning goals

## Project Details

### Student Understanding Interviews

- Interview students about their computational understanding
- Develop categories of students' computational understanding
- Reported computational difficulties help form the basis for assessment development

### Possible Papers

- AJP article - reported computational difficulties
- PR-PER article - detailed results conceptual interview of students around computational understanding

## Project Details

### Assessment Construction

- Development of assessment informed by faculty goals and student understandings
- Development of web framework for deployment and analysis of assessment
- Pilot testing with students to check further develop initial framework

### Possible Papers

- Some Ed Tech article - centralized assessment of computational understanding
- PERC paper - Initial assessment development from goals and understandings
- PERC paper - Results of pilot testing and changes made

## Project Details

### Validation Interviews

- Interview faculty to validate preliminary assessment
- Interview students to validate wording and what meaning can be made from answers
- Make alterations as needed

### Possible Papers

- PERC paper - Discussion of changes made to assessment based on interviews

## Project Details

### Rasch Analysis

- Pilot assessment with partners
- Perform analysis using Rasch tools developed for the assessment and web framework
- Continued use of assessment and validation with Rasch analysis

### Possible Papers

- PR-PER article - Use of Rasch analysis to develop assessment; detailed analysis of questions and choices made
- PR-PER article - presentation of the assessment and its development
- AJP article - presentation of assessment and important results
- Some Ed Tech article - how Rasch analysis is used and deployed in web framework for assessment

## Project Details

**Evaluation and Further Studies**

- Demographic and Cross-institutional analysis of existing data
- Cross-sectional and longitudinal studies
- Comparative students

PR-PER and AJP articles - as completed

## Project Details

**Necessary technological supports**

In order to perform analysis and deploy (and score) the assessment in a centralized manner, we will need to:

- develop a set of open-source tools for Rasch analysis (e.g., using Python),
- develop a web framework for the construction and deployment of assessments (e.g., using devilry and additional tools),
- develop a set of open-source analysis tools that generate reports for faculty (e.g., devilry, doconce, and additional tools), and
- develop a set of open-source analysis tools that allow us to answer broader questions by pooling data across faculty users.

## Project Timeline

- **Semester 1:**
  - Develop protocol for faculty and student interviews
  - Interview students and faculty

## Project Timeline

- **Semester 2:**
  - Perform analysis of faculty and student interviews
  - Identify faculty goals and preliminary categories of student understanding
  - Continue phenomenographic analysis of faculty and student interviews

## Project Timeline

- **Semester 3:**
  - Develop preliminary assessment questions
  - Validate assessment with faculty and student interviews
  - Identify partners for initial data collection
  - Continue phenomenographic analysis of faculty and student interviews
  - Begin development of web framework for delivery and analysis

## Project Timeline

- **Semester 4:**
  - Pilot assessment with partners
  - Obtain feedback on usage
  - Perform Rasch analysis on preliminary data to identify assessment items to review
  - Alter problematic items as needed
  - Revalidate assessment with student and faculty as needed
  - Continue to identify partners
  - Complete phenomenographic analysis of faculty and student interviews

## Project Timeline

- **Semester 5:**
  - Launch second pilot assessment with partners using updated web framework, assessment, and analysis tools
  - Perform Rasch analysis on second round of data to identify assessment items to review

  - Alter problematic items as needed
  - Revalidate assessment with student and faculty as needed
  - Continue to identify partners
  - Develop tools for cross-institutional and demographic analysis
  - Begin preliminary investigation of cross-institutional and demographic effects

## Project Timeline

- **Semester 6:**
  - Launch near final assessment with partners using updated web framework, assessment, and analysis tools
  - Perform Rasch analysis on second round of data to identify assessment items to review
  - Alter problematic items as needed
  - Revalidate assessment with student and faculty as needed
  - Perform cross-institutional and demographic analyses
  - **Finalized assessment completed by end of semester**

## Proposed Project Resources

- Danny Caballero
- Postdoc (to lead on project - need PER background)
- PhD student 1 (PER with qualitative emphasis) - Dissertation: Categories of faculty's computational goals and student computational understandings for course X
- PhD student 2 (PER with quantitative emphasis) - Dissertation: Development of assessment of students' computational understanding in course X
- Master's students (PER, Computational, Web) - Projects: Development and deployment of analysis tools, web framework, testing usability, etc.