Introducing the virtual Distraction Driven Development (D^3) toolkit for developing Standardized Conceptual Learning Assessments (SCLAs)

Mayuri Gilhooly[1], Andrew J. Mason[2], Liam G. McDermott[3], Daniel Young[4], Rebecca Lindell[5]

1: University of New England, 2: University of Central Arkansas, 3: University of Connecticut– Avery Point, 4: Westminster University, 5: Tiliadal Solutions, LLC

The Distraction Driven Development (D^3) toolkit is a Shiny R-based application that enables Standardized Conceptual Learning Assessment (SCLA) developers to upload their data and instantly generate a comprehensive analysis report. The complete toolkit will support non-parametric approaches to Classical Test Theory (CTT), Item Response Theory (IRT), Differential Item Functioning (DIF), and Concentration Analysis (CA). Additional development tools will be added to D^3 in the future. Currently, the tool focuses on Concentration Analysis, offering researchers a robust, interactive framework to guide SCLA development [1]. It accepts two csv inputs - student responses and an answer key- and produces item-level metrics, visualizations, and diagnostic tables based on the CA framework. This initial implementation of the CA module is open source, designed for transparency and flexibility, and supports tiered question formats common in conceptual assessments. This poster presents the functionality, technical design, and application of the CA module.

CA Module

- Designed to analyze tier 1 data from a two-tier model.
- Resides within an R `.qmd` (Quarto Markdown) file and uses the Shiny framework, which enables the creation of interactive web applications.
- Calculates CA metrics (concentration factor, Score) [1], and interpretation of item-level patterns through tables and visualizations.

User Inputs	Dataset 1: Student Responses Dataset 2: Answer Key
Output: Table 1	Question #, n_i counts (no. of students for each choice), m – no. of choices per question, answer key, N S, C S, C ranks (“L”, “M”, “H”)
Output: Visualizations	S-C
Output: Table 2	Grouped questions based on S-C patterns (HH, LH, MM, …)

Technical Design

The Quatro .qmd file for CA module is organized into six key components: 1. Metadata and configuration (YAML Header), 2. Global Setup Chunk, 3. Narrative Text and Equations, 4. User Interface (UI) Input Section, 5. Reactive Data Processing, 6. Output Rendering and Visualization.

Application

Test data: anonymized two-tier responses for 59 questions from a conceptual learning assessment.

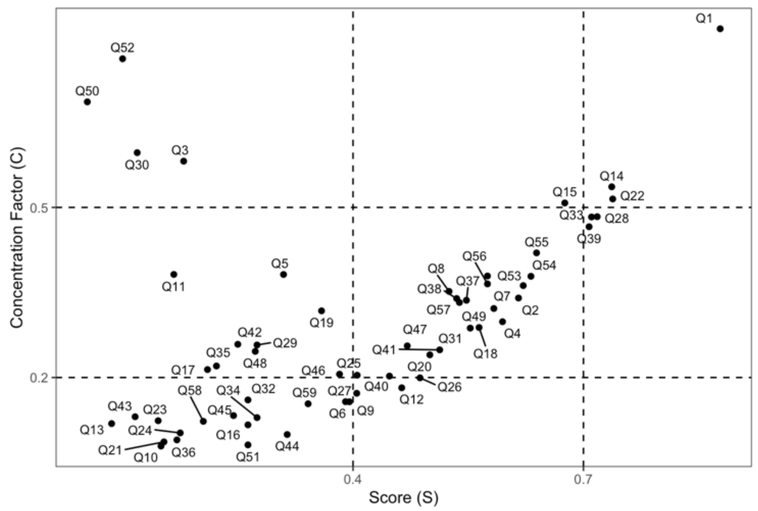

Fig 1: S-C plot with item numbers

Question	m	key	N	C	S	S_rank	C_rank
Q1	8	F	41	0.815	0.878	H	H
Q2	4	A	39	0.34	0.615	M	M
Q3	4	C	39	0.581	0.179	L	H
Q4	4	A	37	0.298	0.595	M	M

Output Table 1: concentration analysis metrics – Score: S, Concentration factor: C and S, C ranks (“L”, “M”, “H”)). For the scores (L: 0 – 0.4, M: 0.4 – 0.7, H: 0.7 – 1) and concentration factors (L: 0 – 0.2, M: 0.2 – 0.5, H: 0.5 – 1) was used as described in Reference.

HH	LH	MM	LM	LL	HM	MH	ML	HL
Q1	Q3	Q2	Q5	Q6	Q28	Q15	Q12	
Q14	Q30	Q4	Q11	Q9	Q33		Q26	
Q22	Q50	Q7	Q17	Q10	Q39		Q27	
	Q52	Q8	Q19	Q13				
		Q18	Q29	Q16				

Output Table 2: questions according to their S-C patterns (HH, LH, MM, …) with S rank first.

As an open-source R based Shiny application, this tool is customizable and reproducible.

Reference

[1] Bao, L., & Redish, E. F. (2001). Concentration analysis: A quantitative assessment of student states. American Journal of Physics, 69(S1), S45-S53.