Project Proposal: Post-marking Analyses using Automated Guttman Charts

Motivation

Post-marking analyses can empower educators with key insight into learners' progress and facilitate subsequent intervention designs. The implementation of assessment rubrics (see Appendix A) has been gaining wider acceptance in recent years, where learners develop meta-cognition through modelling "things my teacher looks for in a good essay" and how each marking criterion can be achieved at various success levels (final column in Appendix A). Evidence-based grading can then be carried out with transparency and accessibility to learners, parents, and school leaders.

In addition to computing sum scores, rubrics-based marking leaves behind a rich collection of learner data. A Guttman analysis takes in every learner-by-competency observation and visualise class-level performance patterns into a useful map (Guttman chart, Appendix B). The zone of proximal development (ZPD) can then be identified as the transitional region from "grass land" (zone of actual development, ZAD) to "desert". By grouping students with similar learning needs (blue, orange, and green boxes in Appendix B), interventions can be carried out with high precision and efficiency.

Even more, systematic difference in visual patterns may reveal latent issues beyond the current assessment. Separate Guttman charts can be generated by sex ("Do girls do better in this psychology essay than boys, at which competencies, hence how do I adapt my teaching next to ensure success for all?"), by classrooms ("Class D's history classes are all scheduled in the final period. Does this timetabling issue translate to poorer learning outcome?"), or by cultural/aboriginal identity ("This competency demand appeared to be particularly difficult for certain subgroups. Should we consider fairness issues in the next round of assessment design?"). Underutilising post-marking analyses leaves too many improvement opportunities unexplored.

Problem Statement

Guttman charts, unfortunately, are rarely produced by front-line teachers. A manual compilation of a Guttman chart routinely takes half a day—a prohibitively costly exercise in terms of teachers' time. Machine time, on the other hand, is well suited for post-marking analyses because the steps are highly procedural, predictable and programmable. This project proposes a digital learning management system (LMS) solution that turns post-marking analyses from hour-long "nice to have" to a click-a-button "must have"—shorthand "AutoGuttman" from now on.

Product Description

By incorporating itself to the existing LMS, AutoGuttman can take over post-marking analyses by reading in each learner's rubrics marks into a two-dimension array (row = learner, column = assessment competency/task). Next, a sorting dictionary will rearrange rows and columns in descending order by row-sums and column-sums. Colour schemes will then be applied to the Guttman chart to mark can-do from cannot-do (see Appendix B for visual effect). Using Java Script and CSS, these tasks can be completed in seconds for an average-size classroom in Norwegian high schools (Year 8—10 grunnskole, and VG). If desired, teachers, year leaders, and school principals can request differential analyses by sex, classroom, or other demographic attributes as illustrated in this prototype: https://engagelab.uio.no/AutoGuttman/#/ (Due to an expired API key, the graphical front-end has lost connection with the back-end nettskjema where the mock data were stored. This website could be quickly restored once funding resumes.)

As a future development goal, AutoGuttman can take advantage of the proliferation effect to further reduce implementation costs. Since rubrics and Guttman charts are stored as database files, teachers can download existing rubrics, drag-and-drop/type-over, and re-publish their designs at near-zero cost. A GitHub-like community may soon emerge as the central repository, paving the way for featured assessment designs and the associated post-analyses. Practices and data from this community could enable further educational research on atomic-level competency development, and inform the curriculum authority about how the national learning strategies are implemented at the grass-root level.

Budget

Engagelab charges internal projects at Lønnstrinn 69 (approximately 600 to 700 NOK per hour). A functioning AutoGuttman beta release requires front-end graphic designers (student-facing and teacher-facing pages, with the latter having design mode and marking mode) and back-end database manager (data capturing, efficient sorting dictionary, Feide access security, data protection (especially important since we process data from young learners under 18), data backup and access log maintenance). I am too inexperienced to estimate the total developer-hours required so I defer this judgement to the Faculty in consultation with EngageLab.

Planned Partners

In addition to UV's EngageLab, legal expertise shall be sought for the purpose of drafting end-user agreements, as well as compliance audits with GDPR and Norwegian privacy laws. Data custody must be agreed upon before beta release, including legacy protocol should this project cease functioning. Similarly, I refer cost estimation to the expert.

Appendix A

Example Rubrics

				5.3 Generalises from the analysis to determine suitability				9.4 Explains the synthesis of the factors involved in making divisions between ZPD groupings				Generalises from a Guttman analysis to inform assessment and teaching	24-25	H1
						7.2 Reconciles Guttman data with pairwise comparison			10.3 Provides scaffolds required to achieve next step in learning	11.3 Provides scaffolds required to achieve next step in learning		Reconciles information in Guttman chart to provide scaffolds to achieve next step in learning	21-23	H1
			4.2 Explains the patterns of ones and zeros to evaluate performance of items		6.2 Explains the patterns of ones and zeros to evaluate the accuracy of the data							Evaluates by analysing features of the Guttman chart	19-20	H2A
				5.2 Explains the features of the Guttman chart to evaluate the suitability of the task				9.3 Uses patterns within the Guttman chart to justify grouping decisions				Discusses features of the Guttman chart to explain decision making	17-18	H2B
							8.2 Assesses extent to which Guttman chart can be used to form ZPD groupings		10.2 Uses ZPD to identify the next step in learning	11.2 Uses ZPD to identify the next step in learning	12.1 Uses language consistent with a developmental model of learning	Uses the Guttman analysis to identify developmental learning goals	13-16	H3
			4.1 Reviews item performance to determine suitability	5.1 Reviews the match between the task and the student abilities	6.1 Comments on the accuracy of the data		8.1 Comments on the suitability of this task for determining ZPD of individual students	9.2 Shows ZPD groupings				Uses the Guttman chart to interpret item and student performance	8-12	P
1.1 Submits Guttman chart that uses dichotomous format	2.1 Submits Guttman chart with students sorted	3.1 Submits Guttman chart with items sorted				7.1 Discusses relative difficulty of items		9.1 Refers to trend in student ZPD	10.1 Identifies area(s) for improvement	11.1 Identifies area(s) for improvement		Recognises the components of a Guttman chart.	1-7	N
Insufficient Evidence	Insufficient Evidence	Insufficient Evidence	Insufficient Evidence	Insufficient Evidence	Insufficient Evidence	Insufficient Evidence	Insufficient Evidence	Insufficient Evidence	Insufficient Evidence	Insufficient Evidence	Insufficient Evidence			N
1. Checks Guttman chart uses dichotomous format	2. Checks Guttman chart has students sorted	3. Checks Guttman chart has items sorted	4. Reviews the suitability of items based on their performance	5. Reviews the suitability of this task to determine the ZPD of all students	6. Discusses the impact of 'noise' on the data	7. Reviews relative difficulty of items between pairwise comparison and Guttman chart	8. Reviews the extent to which the Guttman chart for this assessment can be used to determine the ZPDs of individual students.	9. Identifies ZPD groupings	10. Gives feedback to Student 1	11. Gives feedback to Student 2	12. Uses developmental language to express feedback			
Checks Guttman Chart			Uses assessment data to review quality of assessment task and its implementation				Reviews student performance		Provides feedback using language of the developmental model of learning					

Appendix B

Example Guttman Chart

Goals	Zone 1: Construct Guttman chart											Zone 2: Identify students' ZPDs based on Guttman chart								Zone 3: Explain and justify your decisions base on Guttman chart			Zone 4: Theorise and extend your teaching intervention based on Guttman chart		
Student	1.1 Submits Guttman chart that uses dichotomous format	2.1 Submits Guttman chart with students sorted	9.1 Refers to trend in student ZPD	10.1 Identifies area(s) for improvement	11.1 Identifies area(s) for improvement	3.1 Submits Guttman chart with items sorted	7.1 Discusses relative difficulty of items	5.1 Reviews the match between the task and the student abilities	6.1 Comments on the accuracy of the data	8.1 Comments on the suitability of this task for determining ZPD of individual students	9.2 Shows ZPD groupings	10.2 Uses ZPD to identify the next step in learning	11.2 Uses ZPD to identify the next step in learning	12.1 Uses language consistent with a developmental model of learning	5.2 Explains the features of the Guttman chart to evaluate the suitability of the task	11.3 Provides scaffolds required to achieve next step in learning	10.3 Provides scaffolds required to achieve next step in learning	8.2 Assesses extent to which Guttman chart can be used to form ZPD groupings	9.3 Uses patterns within the Guttman chart to justify grouping decisions	6.2 Explains the patterns of ones and zeros to evaluate the accuracy of the data	4.2 Explains the patterns of ones and zeros to evaluate performance of items	7.2 Reconciles Guttman data with pairwise comparison	9.4 Explains the synthesis of the factors involved in making divisions between ZPD groupings	5.3 Generalises from the analysis to determine suitability	r.sum
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	22
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	22
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	22
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	22
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	0	21
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	21
19	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	21
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	21
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	21
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	0	1	20
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	0	20
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	20
1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	0	0	1	19
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	19
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	0	1	0	1	0	0	19
11	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	0	0	19
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	19
13	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	1	1	1	0	0	1	19
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	1	1	0	0	19
2	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1	0	0	0	18
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	1	0	0	19
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	0	0	0	0	18
28	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	18
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	1	1	0	0	0	17
10	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	0	0	1	0	0	17
15	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	0	1	0	0	0	0	17
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1	0	0	1	0	0	17
18	1	1	1	1	1	1	1	0	0	1	1	1	0	1	0	0	0	0	1	0	0	0	1	0	13
3	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	12
25	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	12
c.sum	30	30	30	30	30	29	29	29	29	29	28	28	27	26	22	22	21	20	20	18	15	15	4	3	