

## **Qualitative content analysis of lab report discussion in introductory physics for engineering and technology students**

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# **Qualitative content analysis of lab report discussion in introductory physics for engineering and technology students**

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## **Abstract**

The discussion section of a student's lab report have been assessed with the Mayring methodology and associated software for qualitative content analysis. An example of the categorization and coding procedure is discussed via a lab example of energy conversion from potential to kinetic. The software results were tabulated using the Torrance Creativity Test criteria to evaluate qualitative content in terms of critical thinking and creativity. Furthermore the Torrance scores were used as inputs into a causative structure model to assess "Learning with Intent", together with "Critical Thinking" manifested in calculation tasks. Although the Intent Aptitude assessment model would require more data collection to confine the loading value of the Critical Thinking Aptitude onto Intent Aptitude, the combination of Mayring methodology and Torrance Creativity Test has been shown to be a working platform for assessing the writing content qualitatively in introductory physics for engineering and technology students.

## **Keywords**

Mayring's software, qualitative content analysis, Torrance creativity test, structural equation model

## **Introduction**

Academic misconduct has always been an issue when instructors are required to maintain fairness. In fact, a recent finding showed that it is the high achiever that would have a higher tendency to cheat, a break from the traditional viewpoint that low achievers would cheat more often<sup>1</sup>. City University of New York has a writing intensive requirement and physics lab report writing would be acceptable for meeting that writing requirement<sup>2</sup>. The resubmission is dedicated by the writing intensive policy such that our community college has tutorial center where writing tutor would help a student in the first submission as well as in the resubmission. Given that professors are faced with these challenges, it is important to develop a qualitative content analysis methodology. Our department also has a regrade policy where the chair will appoint regrade committee members to process a regrade request, and a clear methodology for essay grading is practical. The learning style myth has been analyzed and recent findings have reasoned that it is a myth<sup>3,4</sup>. Therefore a uniform qualitative content analysis methodology would not be bias against various learning styles.

In a 2016 July Money Magazine and Barnes Noble College survey, it was found that students and parents share common viewpoints on what are the top three benefits of college education, as seen in Figure 1 <sup>5</sup>, and students put connection and experience more important than higher salary <sup>6</sup>. The critical thinking element, valued by students and parents, could be assessed with qualitative content analysis when there is a student lab report discussion.

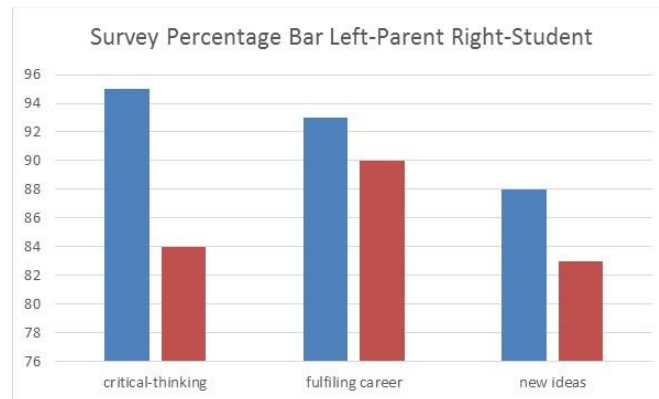


Figure 1: Survey Percentage result of 2016 July Money Magazine- Barnes Noble College illustrated as vertical bars for easy viewing. The margin of error was reported to be 3.1 points for students and 3.7 points for parents

### The Mayring Methodology

The Mayring methodology has been used to evaluate nursing student writing <sup>7</sup>. For deductive content analysis, the basic idea involves giving explicit definitions, examples and coding rules for each deductive category. The instructor user would decide under what situation a text string can be coded as fulfilling a category, based on the instructor's fluid intelligence. The decision is not delegated to a commercially available artificial intelligence software for qualitative content analysis. The Mayring step model of deductive category application carries one iterative process that allows for a revision of the categories and coding agenda with formative reliability checking <sup>8</sup>. A free online computer software for the Mayring methodology has been available by Mayring since 2014 where a user would code the essay content according to his/her pre-determined coding rules and the resulting statistics would be given in an Excel platform for easy comparison between two essays <sup>9</sup>. The essential real time computer operation step would be user selection of a particular phrase or text string with the computer cursor (mouse). Then the Mayring software would release a small window showing the already defined categories and the user would need to respond in selecting which category to complete the coding process. The flexibility of the coding process is built in such that any text string with meaning only known to the user would work, as seen in Figure 2.

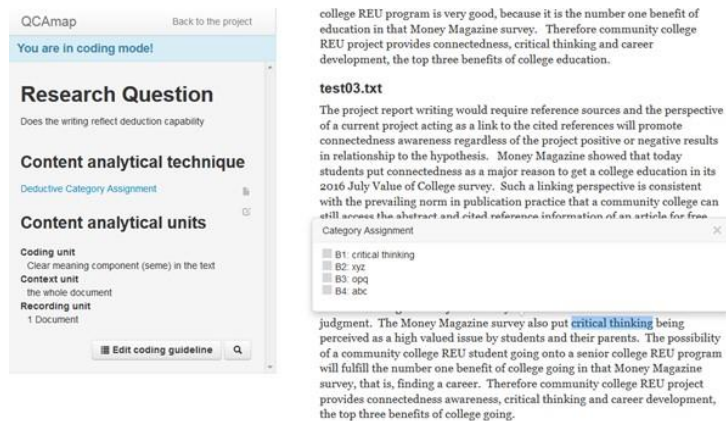


Figure 2: The QCAmap coding page example where the text string ‘critical thinking’ is being selected and the pop-up category window. The other string entries demonstrate the flexibility of the computer program.

## The Implementation

One of our lab exercises is an energy lab where the potential energy drives the motion of a block along an air track. The calculation results from the members of a group should be essentially identical but each student still needs to write an independent discussion. A graph with potential energy PE as the x-axis and the kinetic energy KE as the y-axis would have a slope almost equal to one when the pulley rotational energy is negligible. The intercept should be at the origin and non-zero value would suggest table tilting, block entering detection region before hanging mass reaching the floor, etc. The content categorization and codes are listed, as seen in Table 1.

Table 1: Content Categorization and Codes

Category	Codes
(1) Recognition of intercept	Graph intercept, near origin , non-zero y when $x = 0$ , non-zero x when $y = 0$ , regression line
(2) Significance of intercept value	Table tilting, systematic error existence, inappropriate height, uncertainty, pulley rotational energy
(3) Recognition of slope	Graph slope, tangent, $dy/dx$ , regression line
(4) Significance of slope value	Higher than one, lower than one, faster speed, lower speed, height measurement, inappropriate height, uncertainty
(5) Reflecting: remedy suggestion	Air track adjustment, air hole testing, string not caught on pulley axle, hanging mass misreading, block

	mass measurement error, standard value comparison
(6) Recognition of applied calculus concept	$\delta PE$ , $\delta KE$ , velocity error contributes twice in comparison to height error, linearity of time error, linearity of mass error, linearity of moving distance error

The Excel output of the Mayring software tabulates the category scores which then can be analyzed in terms of critical thinking and creativity. The Torrance creativity test has been used to assess creativity in a school context and bilingual cognitive flexibility<sup>10, 11</sup>. We had selected fluency, flexibility, originality, and elaboration as the scales to evaluate the divergent thinking and other error-source identifying skills. The fluency measures the total number of issues discussed in describing an error/stimuli and would be indicated by Category -1 and Category-3. The flexibility measures the number of categories of relevant suggestions and would be indicated by Category-5. The originality measures the diversity of the proposed possible causes of that issue and would be indicated by Category-2 and Category-4. The elaboration measures the depths or details in the responses and would be indicated by Category-6.

## Discussion

One of our major concerns is “Learning with intent”, which in particular is a major issue in the teaching of technology physics classes. We always remind them that the learning with intent would extend beyond just fulfilling the engineer supervisor’s requests to learning in life. The engineering students know more about the ethical issue of learning in life where learning with intent is the very first step. We had published a causative structure equation model for the assessment of the Hands-on Aptitude and Concept Theory Aptitude with various tasks and 16S rRNA data<sup>12, 13</sup>. The extension to an assessment scheme of Critical Thinking Aptitude and Intent Aptitude using causative structural equation model is illustrated in Figure 3. The trademark LISREL, LInear Structural RELations<sup>14</sup>, has been a popular software package used by researchers for structural equation modeling and our experience showed that Matlab general capability in matrix operation also worked for a small population of about 150 students.

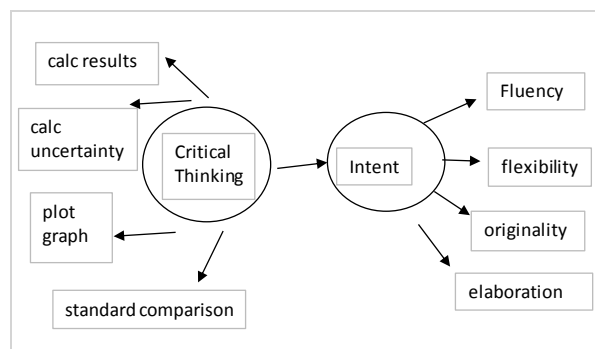


Figure 3: The structure equation model for the assessment of Intent Aptitude.

The above model has been tested with simulated data for stability with  $N = 25$ . Assessment on data for a small engineering class ( $N = 12$ ) showed substantial analysis noise in comparison to a pre-med algebra physics class ( $N = 18$ ). We attribute the difference to the strong pre-med students' motivation. Future studies could include more data collection to build a larger population, addition of English Aptitude latent variable, etc. The content categorization and codes discussed above can be extended to the studying of essay writings in other STEM classes in term of word concreteness, valence, etc., which are observables in the research of memory and affective learning in monolingual and bilingual students<sup>15, 16</sup>.

## Conclusions

The sharing of our example of the categorization and coding procedure in the Mayring methodology could promote qualitative context analysis beyond nursing discipline to STEM. The tabulation of the Mayring methodology results in terms of the Torrance Creativity Test criteria has been found to be applicable for the assessment of "Learning with Intent".

## Acknowledgments

Partial supports from several CUNY grants are acknowledged. We thank Alexei Kisselev for laboratory support. We thank Eric Cheung MD UIC Medical College Psychiatry Department for discussion. We thank the anonymous reviewers for their suggestions.

## References

- 1 Ottawa K, Murrant C, Ritchie K. Cheating after the test: who does it and how often? *Adv Physiol Educ.* 2017 Sep 1;41(3):368-374. <https://www.ncbi.nlm.nih.gov/pubmed/28679574>
- 2 Queensborough Writing Intensive Policy. <http://www.qcc.cuny.edu/WIDWAC/wiGuidelines.html>
- 3 Newton PM, Miah M. Evidence-Based Higher Education - Is the Learning Styles 'Myth' Important? *Front Psychol.* 2017 Mar 27;8:444. <https://www.ncbi.nlm.nih.gov/pubmed/28396647>
- 4 Newton PM. The Learning Styles Myth is Thriving in Higher Education.. *Front Psychol.* 2015 Dec 15; 6:1908. <https://www.ncbi.nlm.nih.gov/pubmed/26696947>
- 5 Money Magazine. What makes a college a good value? Parent and Students share similar goals data table: Top three benefits of college. August 2016 page 52
- 6 Barnes and Noble College Insight. Today's College Students Value Connections and Experiences More Than Higher Salaries. July 13 2016  
<http://next.bncollege.com/todays-college-students-value-connections-experiences-higher-salaries/>
- 7 Itatani T, Nagata K, Yanagihara K, Tabuchi N.. Content Analysis of Student Essays after Attending a Problem-Based Learning Course: Facilitating the Development of Critical Thinking and Communication Skills in Japanese Nursing Students. *Healthcare (Basel).* 2017 Aug 22;5(3).  
<https://www.ncbi.nlm.nih.gov/pubmed/28829362>
- 8 Philipp Mayring. Qualitative Content Analysis. *Forum Qualitative Social Research: Volume 1, No. 2, Art. 20 (2000).* <http://www.qualitative-research.net/index.php/fqs/article/view/1089>
- 9 Mayring Software 2014 [www.qcamap.org](http://www.qcamap.org).
- 10 Ana Paula Cardoso, Paula Rodrigues, Rogério Malheiro, Paula Rodrigues, Sara Felizardo. Assessment and Creativity Stimulus in School Context. *Procedia - Social and Behavioral Sciences.* Volume 171, 16 January 2015, Pages 864-873. <http://www.sciencedirect.com/science/article/pii/S1877042815002323>
- 11 Language Mediated Concept Activation in Bilingual Memory Facilitates Cognitive Flexibility. *Front Psychol.* 2017 Jun 28;8: 1067. <https://www.ncbi.nlm.nih.gov/pubmed/28701981>
- 12 Todd Holden, Vazgen Shekoyan, Sunil Dehipawala, George Tremberger, Jr, David Lieberman & Tak Cheung. An Explorative Structural Equation Modeling of Grades for Engineering & Technology Educational Research. Spring 2012 ASEE Middle Atlantic Section Proceedings Archive Paper #3 (7 pages).  
<http://www.asee.org/papers-and-publications/papers/section-proceedings/middle-atlantic/spring-2012>

- 13 T. Holden, P. Schneider, E. Cheung, J. Prayor, R. Duran, J. Ye, G. Tremberger Jr, D. Lieberman & T. Cheung, A Structural Equation Model Study of Shannon Entropy Effect on CG content of Thermophilic 16S rRNA and Bacterial Radiation Repair Rec-A Gene Sequences. Spring 2012 ASEE Middle Atlantic Section Proceedings Archive Paper #2 (7 pages). <http://www.asee.org/papers-and-publications/papers/section-proceedings/middle-atlantic/spring-2012>
- 14 LISREL <http://www.ssicentral.com/lisrel/>
- 15 Marc Brysbaer, Amy Beth Warriner, Victor Kuperman. Concreteness ratings for 40 thousand generally known English word lemmas. Behavior Research Methods. 2014, Volume 46, Issue 3, pp 904–911 <https://link.springer.com/article/10.3758/s13428-013-0403-5>
- 16 Lydia T.S. Yee. Valence, arousal, familiarity, concreteness, and imageability ratings for 292 two-character Chinese nouns in Cantonese speakers in Hong Kong. PLoS ONE 12(3): e0174569. (2017) <https://doi.org/10.1371/journal.pone.0174569>

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