DEVELOPING AND IMPLEMENTING ASSESSMENT MODERATION PROCEDURES TO EVALUATE WRITTEN LABORATORY REPORTS

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ABSTRACT

In evaluating laboratory reports, assessment criteria must be clearly established and made explicit to students before the lab activities so students can focus their efforts and the instructors will concentrate on major learning outcomes during marking the laboratory reports. This paper is intended to help draw assessment moderation procedures to significantly minimize discrepancies between teachers in marking lab reports. It also helps students to develop their report writing skills. A population of 193 students taking two chemistry laboratory courses and a team of three instructors were used as research group. The students were required to respond on the extent of instructors' subjectivity during marking lab reports, and on its impact on their motivation and learning. Marks given by the instructors to lab reports were compared and evaluated for significant differences. Based on the responses of the students and marks issued by the instructors, a moderation procedure was proposed, implemented and evaluated for its effectiveness in improving students' motivation and learning. The research showed that there is a clear observation and evidence of lack of skills on students' side about report writing before moderation. It also indicated that teachers assessed the reports on subjective basis rather than objectively designed marking criteria. The implementation of the moderation procedure helped reducing the instructors' discrepancies in marking lab reports and brought significant improvements on students' motivation and achievements. *[African Journal of Chemical Education—AJCE 6(1), January 2016]*

INTRODUCTION

Written laboratory reports are among the different types of assessment tasks. A laboratory report is a common way of presenting information and recommendations or conclusions related to a specific purpose. The reports are presented based on gathering and analyzing information using a discipline specific methodology and format. They can also be used to assess field work or case studies. Carefully designed assessment tasks allow students to demonstrate achievement of clearly communicated learning outcomes. The assessment designs should include the following three elements: the learning outcomes must be clear, the learning experiences should help students achieve those learning outcomes, and the assessment tasks must allow students to demonstrate their achievement of the learning outcomes [1].

The laboratory report mark is one obstacle that tends to create conflicts between teachers and students, between students and between teachers. Some way of marking, grading and evaluating pupils' work is necessary. In spite of the long persisting criticisms of laboratory marks for unreliability as well as adverse emotional effects upon learners and teachers, the practical reality of certain contributions of effective assessment procedures in promoting individual learner's own realistic conception of himself/herself is recognized [2]. It is also argued that evaluation is rarely free from personal and other sources of bias. To some extent, these biases are reduced where assessment is shown to be credible, dependable, and confirmable [3].

Moderation, a quality assurance process directed at ensuring that assessments are marked with accuracy, consistency and fairness, is required for every assessment which involves a degree of subjectivity. It is aimed at ensuring that marks and grades are as valid, reliable, equivalent and fair as possible for all students and all markers [4]. Also, it is the most effective criteria used to minimize significant differences in assessing students' works particularly when many teachers

instruct and assess the same course for different classes. Moderation helps to ensure that there is an appropriate focus on outcomes for learners, that learning is at the appropriate level and that learners develop the skills for learning, skills for life and skills for work, including higher order thinking skills, which will allow them to be successful in the future. Teachers involved in developing their assessment approaches through participation in moderation activities acquire a highly effective form of professional development. Efficient and effective approaches to quality assurance and moderation will require building on local practices, developing working approaches across education authorities and partners and linking this work at a national level. [5]

Moderation includes the entire assessment event, including the design and post-event analysis of the fitness of the assessment of student learning. During moderation, assessments are designed so that they are clearly linked to the intended learning outcomes; pre-marking meetings or other activities are undertaken to ensure that assessors are able to clarify their understanding of the assessment criteria; assessment criteria are clearly communicated to students, both in the pre-assessment phase and also when providing feedback; and assessments are subject to regular review: their frequency, style and the relative success rate of students are appraised as a regular part of the improvement cycle. Effective assessment moderation activities are achieved by using marking criteria, discussions of standards, cross marking and avoiding post-hoc adjustment of marks in higher education. The first phase of moderation is to review all lab report items collaboratively with all markers before the assessment is set and make amendments as required. The second phase of moderation is the implementation, marking and grading that is done before marks are allocated. If there are multiple markers, conduct a consensus marking exercise such as double or triple marking a sample of anonymous items and compare marks, comparing marking

ranges across different groups and markers and giving timely and sensitive feedback to learners and markers [6].

Marks and grades given to students are commonly made by subject specific decision making processes as judgments about academic standards [7]. Ensuring consistency of assessments in a unit is a challenge when a unit is offered on more than one campus and by more than one marker [8]. Marking and grading in most disciplines is inevitably subjective [9] but a systematic approach to identifying significant tacit beliefs may assist in reducing the effect on variation [10]. Conversations amongst markers assessing student performances influenced how the group of markers reached agreement [11]. Despite the potential benefits of team work, moderation of marking is essential for students to feel confident that they will be rewarded fairly for their contributions and that any 'free---riders' will not benefit from the efforts of others.

PURPOSE, RESEARCH QUESTIONS AND METHODOLOGY

The aim of the research is to find out the level of teachers' subjectivity in marking laboratory reports and its impact on students' learning. It also tries to assess some moderation activities that promote students' laboratory report writing skills and their motivation to learn through practice by reducing teachers' subjectivity in marking laboratory reports in chemistry laboratory sessions.

The research is intended to give answers for the following questions:

1. What is the students' perception of teachers' discrepancy in marking lab reports and its impact on learning?
2. What is the level of discrepancies between teachers, and within themselves, during marking lab reports?

3. Do the proposed assessment moderation procedures help minimizing the inconsistency between teachers in marking lab reports?
4. What is the effect of assessment through moderation on students' learning and motivation?

The research was carried out in Debre Markos University, Ethiopia. It is an evaluative type study consisting of a population of 193 students who completed two consecutive laboratory courses, and a team of three instructors. Four 5-scale Likert style questionnaires were prepared to be filled by students. . In the questionnaires, strongly agree (SA) had 5 points, agree (A) 4 points, neutral (N) 3 points, disagree (D) 2 points and strongly disagree (SD) 1 point. Questionnaire 1 assessed the students' perception of the discrepancies between instructors in marking lab reports. Questionnaire 2 asked students responses on the effect of the discrepancy on their motivation and achievement. Questionnaire 3 consisted of ten items. It was aimed at evaluating the students' attitudes towards the proposed assessment moderation procedure. The reliability and validity of the items in the instrument were evaluated by calculating the Cronbach's alpha coefficient. Questionnaire 4 emphasizes the effect of the proposed moderation on students' achievement.

In addition, triplicate copies of 6 lab reports of three groups of students were each marked by the three instructors before and after implementation of the procedure. The results were recorded and evaluated for significant discrepancies between the instructors' markings using a paired student's *t-test* statistics.

RESULTS AND DISCUSSIONS

In this section, data are presented based on which answers to research questions are discussed. The results are presented and discussed below.

1. Students perception of discrepancies between teachers in marking lab reports and its impact on their learning

As shown in table 1 below, 153 out of 193 students (79.27%) have agreed that there is significant subjectivity from instructors in marking lab reports and 8 (4.15%) students argued that there is no subjectivity from instructors in assessing students' lab reports. 32 (16.58%) of the students responded that they have no idea regarding teachers subjectivity in assessing reports. The results in **table 2** indicated that of the 153 students who claimed the presence of instructors' subjectivity, 80 students (52.28%) responded that their motivation and achievement has been affected; 41 (26.80%) have no comment and 32 (20.92%) said their motivation and achievement is not affected by subjective assessment methods during marking lab reports.

Table 1: Students' perception of teachers' subjectivity in marking lab reports before moderation: Is there discrepancy, among teachers, during marking lab reports?

SA	A	N	D	SD	Average	sd
39	114	32	8	-	3.95	0.5343

Table 2: Students responses on effects of discrepancy on their motivation and learning
If your response for subjectivity is SA or A, does it affect your motivation and achievement?

SA	A	N	D	SD	Average	sd
22	58	41	20	12	3.38	1.12

2. Students' responses on the proposed assessment moderation strategies

After evaluating the reliability and validity of the pilot questionnaire using Cronbach's alpha, a six item questionnaire was administered and distributed for students to respond. As shown in table 3 below, 131 out of 153 (85.61%) the students demand the instructors to provide clear instructions and all necessary information before submission of the lab reports. 9.16% have no opinion, and 5.23% showed disagreement about the idea of clear instructions and essential information for lab report writing.

Another proposed item that receives good attention was marking all students' reports of the same experiment by the same instructor. 75.16% of the respondents claim their agreement, 10.56% have no idea, and 14.38% did not support the idea. Even though a smaller number of instructors are advisable to assess the same subset of lab reports, research has shown that same instructor marking is not applicable for a large number of students-to-faculty ratio case [12].

The other well rated proposed procedure by the students was provision of specific lab report formats. 69.9% remarked they needed specifically designed lab report formats, 11.11% were neutral and 19.61% responded negatively. Availability of specific lab report formats helps students to be specific and concentrate on major issues of the report. It also makes the teachers at ease in comparing students work as they focus on similar parts of the report. Laboratory reports should always be written for the convenience of the reader. Thus, for example, each section of the report should be headlined and the sections should be arranged in an appropriate, easily-understood sequence. In the context of the course for which it is written, the laboratory report serves to describe what the students did during the laboratory session, how they manipulated the raw data, what they identified as their result and what they concluded about the experiment [13].

Instructors' timely and meaningful feedback was the other proposed activity in moderation of lab report assessments. The idea of getting on time and meaningful feedbacks about their lab reports was supported positively by almost 68% of the students. 5.23% of the respondents have no comments and about 25.5% have opposed the procedure. Timely and meaningful feedback is essential to learning and to sound assessment practice. Balancing learning goal and efficiency is a key aspect of effective feedback. The most useful forms of feedback are those which help students learn most effectively and help teachers work most efficiently [14].

Another proposed procedure to reduce inconsistency between instructors during marking lab reports was to use marking guides (criteria). More than 63% of the students suggested that instructors should prepare and use marking guides during assessment of lab reports. Some 24.34% were neutral and the rest 12.5% did not support it. Marking guides make explicit to the students the criteria against which their work will be assessed and they can be a comprehensive and efficient feedback tool. A marking guide is advantageous in that it makes assessment processes open and accountable, provides diagnostic feedback to students and staff on students' learning so far, helps students develop, revise and produce better quality work as they do not have to guess what the assessor is looking for because the most valued outcomes of the assessment are clear. It improves comparability when there are several assessors and can be re-used [15]

Table 3: Students' responses on proposed procedures to minimize teachers' discrepancies in marking lab reports

No	Proposed procedures	Students' responses						
		SA	A	N	D	SD	Av	Sd*
1	clear instructions and all information initially	59	72	14	5	3	4.17	0.872
2	reports of the same experiment should be marked by the same instructor	72	43	16	13	9	4.02	1.71
3	provide lab report marking guide	57	39	37	19	-	3.86	1.097
4	give specific formats for lab report writing	42	65	17	22	8	3.67	1.204
5	give on time and meaningful feed-backs	25	79	8	32	7	3.50	1.166
6	give pre-lab and post-lab exercises	41	49	18	33	12	3.48	1.303

Sd* = standard deviation

Furthermore, 58.8% showed their interest in handing of pre and post lab exercises along with the formal lab procedures. 11.76% remain neutral and 21.57% assert that no pre and post lab exercises are required. For many experiments, students are required to have a complete, written pre lab activity before they are allowed to work on the experiment. In order to truly understand lab and to be able to draw appropriate conclusions, a learner must first carefully consider the how, what and why of a lab practice. Research has shown that students who have a written preparation

for lab are safer, more efficient and have a better understanding of how the lab connects to theory [16].

3. Students' responses on effects of assessment through moderation on their achievement

Depending on results of students' opinions on strategies to minimize discrepancies in marking lab reports, a moderation procedure to assess students' laboratory reports was proposed and implemented. The procedure consisted of providing clear instruction about report writing, specific formats, pre-lab activities and exercises, well designed marking guide (rubric) and immediate and meaningful feedback. The instructions, lab report formats and marking guide are shown in appendices 1 and 2.

The data in table 4 showed 122 students out of 146 (83.56%) have agreed that the proposed assessment moderation helped them improve their report writing skills and achieve better results.

Table 4: Students' responses to the effects of moderation on their learning

Did the instructions, lab report formats, pre-lab activities, feedbacks and marking guides (moderation procedures) provided by the instructors help you improve your skills in writing lab reports and achieve better results? Indicate your marks (out of 60%).

Answer	**Number of students Responding**	**Marks out of 60 %**		
		30-40	41-50	51-60
Yes, very well	32	-	19	13
Yes, to some extent	77	-	51	26
No, I achieve better by my own effort	13	2	4	7
No, it doesn't help me	10	2	5	3
No, the instructors become more strict	14	1	8	5

Thirty two students (21.9%) remarked it helped them very well, 77 students (52.7%) responded the moderation made them improve to some extent, 13 students (8.90%) have shown improvement but they argue it came from their own effort. 24 students (16.44%) responded negatively. 14 (9.59%) claimed the procedure made instructors more strict during marking the reports. Students' results shown in **table 5** also indicated that they have made significant improvements after the implementation of the assessment through moderation. The students'

responses on the effects of the moderation activities on their achievement match with findings of research [12, 15].

Table 5: Average marks (out of 10%) issued by different instructors before (1) and after (2) moderation procedures

Experiment No	Before/after moderation	Mark given by three Instructors		
		A	B	C
1	1	7.83 ± 0.29*	8.67 ± 0.29*	6.17± 0.29*
	2	8.33 ± 0.29	8.17 ± 0.76	8.33 ± 0.29
2	1	7.33 ± 0.76	8.17 ± 0.29	6.83 ± 0.29
	2	7.83 ± 0.86	9.17 ± 0.29	7.17 ± 0.76
3	1	8	6.83 ± 0.29	6.5 ± 0.87
	2	8.67 ± 0.29	9.17 ± 0.58	8.17 ± 0.86
4	1	7.5 ± 0.5	7.17 ± 1.04	6 ±0.50
	2	8 ± 0.5	8.83 ± 0.29	8 ± 0.50
5	1	7.83 ± 0.64	8 ± 0.5	6.5 ± 0.50
	2	8 ± 0.5	9	9 ± 0.50
6	1	8 ± 0.5	7.67 ± 0.58	6.5 ± 0.87
	2	9 ± 0.5	9.33 ± 0.29	8.83 ± 0.21
Average	1	7.75 ± 0.51	7.67 ± 0.57	6.42 ± 0.60
	2	8.42 ± 0.37	8.95 ± 0.44	8.25 ± 0.57

***** *Standard deviation*

4. Comparison of discrepancies between and within instructors in marking lab reports before and after moderation

When assessing multidisciplinary lab reports, instructors with different backgrounds can focus on different aspects of the report and they can use different marking criteria. These discrepancies have traditionally been analyzed by calculating and comparing the mean and variance of the marks of each instructor. In a lab course with a high student-to-teacher ratio, the number of lab reports to assess is too large for the available advising hours, so the usual procedure adopted is to have a large number of instructors involved in the course. However, the larger the number of instructors, the higher the risk of marking discrepancies is [12].

Differences between the mean values of the various marks students received in this study were evaluated by student's paired *t*-test. In pair-wise student's *t*-test, the experimental t-statistic value is calculated using the equation:

$$t_{exp} = \frac{x_1 - x_2}{\sqrt{AxB}}$$

Where A = $\frac{n1+n2}{n1.n2}$ and B = $(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2$

The number of degrees of freedom for finding the *t* values is $(n_1 + n_2) - 2$, where n_1 and n_2 are number of replicate copies of lab reports marked by instructor 1 and 2 respectively, and s_1 and s_2 are the corresponding standard deviations. If t_{exp} is smaller than the tabulated t value at 95% confidence level, no significant discrepancies between the two means has been observed. On the other hand, if t_{exp} is greater than the value obtained from table indicates that there is a significance difference between the means.

The data of table 6 indicated the prevalence of significant discrepancies between instructors during marking lab reports. Instructors A and B made significant differences in three of six lab reports before the moderation procedures as compared to only one significant difference after moderation. Also, three significant differences were observed between instructors A & C, and B & C each before moderation. No significant discrepancies were seen between A & C after moderation while one significant difference occurs between B & C. Concerning the overall averages, significant differences were made between A & C and B & C before moderation but no differences are made after implementation of moderation.

The results in **table 7** also indicated that there were discrepancies within instructors themselves before and after implementation of the assessment procedure in marking lab reports. There was only on significant difference within the marks given by instructor A while four significant differences were observed (out of six) within the marks delivered by each of instructors B and C. The statistical data showed the proposed procedure helped reducing the discrepancies made between a number of teachers providing the same course for different groups and classes of

students. This fact is especially relevant when the marking workload is large and does not allow each lab report to be assessed by few instructors.

Table 6: Pair-wise comparison between mean values of marks issued by different instructors using statistical student's t values at the 95% confidence level before (1) and after (2) moderation (student's *t-statistics* at 95% CL for 4 degrees of freedom is 2.78)

Averages compared	**Before/after moderation**	**Experiment No**						
		1	2	3	4	5	6	Av.
	1	3.55*	3.55*	6.99*	0.49	0.36	0.75	0.18
A vs. B	2	0.34	2.56	1.33	2.49	3.46*	0.75	1.60
	1	4.77*	1.06	2.96*	3.67*	2.77	2.59	2.93*
A vs. C	2	0	0.99	0.95	0	2.45	0.42	0.43
	1	10.56*	5.66*	0.62	1.76	3.67*	1.94	3.18*
B vs. C	2	0.34	4.26*	1.67	2.49	0	2.42	1.68

*significant differences exist between the mean marks

Table 7: Pair-wise comparison between mean values of marks issued by the same instructor before and after implementation of moderation using statistical student's t values at the 95% confidence level (student's *t-statistics* at 95% CL for 4 degrees of freedom is 2.78)

	Experiment No						
Instructor	1	2	3	4	5	6	Av
A	2.11	0.85	4.00*	1.22	0.36	2.45	2.28
B	1.06	4.22*	6.25*	2.66	3.46*	4.43*	3.89*
C	9.12*	0.72	2.36	4.90*	6.12*	4.51*	3.83*

*significant differences exist within the mean marks

CONCLUSIONS

The researcher who was involved in the preparation and implementation of the moderation procedure reported the following conclusions and recommendations.

- One of the keys to success (or failure) of moderation of assessments in written subjective assessments seems to be related to the manner in which they were implemented and how well the students were instructed about how to use the procedures. The instructors reported they believed that 1st year students require more guidance and instruction about report writing.

- Another key to the success of the rubric is the experience that the students have with the material. For students with little experience with an assignment such as lab reports, material such as sample reports or checklists are needed to supplement the formats and marking guides as a tool for students to understand what is expected with an assignment.
- Lab reports marked with a marking guide typically had a larger spread in marks than assignments corrected without a marking guide. This appeared to be caused by the instructor being forced to apply a predetermined standard with a marking guide. It was easier as a marker to give a high or low mark on an element of an assignment when it was clear what the standard was. One result of the marking was that the students had set standards to work toward which resulted in better reports by the end of the semester than semesters without formats and guides.
- Instructors collaboration during the development and implementation of assessment through moderation appear to be important to the standardization of the marking. In the case of a lab course, the team of instructors discussed the rubrics including the rationale behind the objectives and criteria. These efforts seemed to be important in the relative success of using moderation to standardize the marking. In the absence of assessment through moderation, the students had many complaints about non-consistent marking with different instructors.
- The students appeared to pay more attention to the criteria when they were given the formats and marking guides well in advance of the report writing and asked to use them to evaluate their own work prior to handing in the lab reports.
- Once students become comfortable with instructions, lab report formats and marking guides, they can provide valuable feedback in the moderation refinement process. The

students in each of the lab experiments provided ample feedback and opinions, some of which were very useful to the refinement process. For example, it became especially clear, that the first year students needed extra support and detail in the moderation.

- Comprehensive and well-written instructions, lab formats and marking guides can help the students understand the professional standards under which their future work as practicing chemists will be evaluated.

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Appendix 1: Instructions and lab report formats

Title	Specific, clearly conveys purpose of lab, can be abbreviated on subsequent pages.
Date	On first page, original date of starting lab activities
Lab Partners	Clearly listed on first page of lab report
Purpose	One sentence or two explaining the purpose of the experiment or the problem being investigated, Be specific but concise, this should relate directly to the conclusion you will draw, you may want to add to or change your purpose after completing the lab.
Materials	Complete list in columns or bullets
Procedure	Written as a list of numbered steps. Steps taken are specific enough so that someone not familiar with the lab or your work could do the procedure and repeat your results, Changes to procedure within a trial can be documented in observations, and you may need to include safety procedures if any.
Data Tables	Make table(s) large enough to write in, You may have to create your own table(s) if one is not given on your manual before coming to class.

Title: Placed at the top of the first page, this should include the title of the experiment, the name(s) of the person(s) performing the experiment, and the date it was performed.
Objective: This is a statement of the purpose of the lab. What are the main reasons you are performing this experiment? Be specific...don't just restate the title or copy the generic objectives from the given lab manual.
Equipment: A bulleted list of all the equipment and chemicals you will use in this experiment
Procedure: A numbered sequence of steps you followed as you perform the experiment. Try to be brief, but include enough detail in passive voice so others can follow this in the lab.
Data / Observations: This is where you record all the measurements and observations you made during the lab, and attach any tables, graphs and charts generated during or after the lab to display your data. All data should be organized into labeled data tables with correct significant figures and labeled units. Graphs and charts must include titles, axes labels and units where applicable.
Calculations: You must show at least *one* sample calculation for each piece of data in your table that was not simply a measured value. For example, if you record the number of moles of NaCl, but you obtained that from measuring the mass of NaCl, you must show in the calculations section *how* you got the number of moles from the mass. If you did this step in five different trials, only one sample calculation is sufficient.
Data Analysis: This is the main part of the lab report where you *present* the data you collected, *discuss* how you obtained the data (explain calculations, but don't restate procedure) and *analyze* why the data is relevant. This section of the lab should contain only statements you can support with your data, NOT your opinions. Every statement should be backed up by quoting your data and/or referencing by title, relevant tables, charts or graphs within your report. For example, in your "data" section you recorded the freezing point of unknown sample #1 to be -5 ^{o}C. In the "data analysis" section you will further analyze that data: "We used an electronic temperature probe and determined the freezing point of sample #1 to be -5 ^{o}C as noted in Figure 2 by the flat portion of the curve. This shows that the addition of a solute (NaCl) lowered the freezing point by 5 ^{o}C when

compared to the curve of the pure sample shown in Figure 1." This will undoubtedly be the longest and most difficult section to write up in every lab report.

Conclusion: This is a brief paragraph where you: restate your objective, quote data that proves you met or did not meet the objective, describe possible sources of error and how they affected your data and suggest how to improve your results if you were to repeat the experiment

Appendix 2: A marking guide to a lab report

Heading	Criteria	Performance level	Points
Aim/objective	Purpose of the experiment stated in one's own words using clear, simple sentences	No ---------- Good ---------- Very good ---------	0 1/2 1
Introduction	Conceptuality, relevance to topic significance, language usage, clarity citation available	 Good ---------- Very good ---------	 1/2 1
Methods/ Procedures	Detailed steps written in passive voice Methods of data analysis included Relationships between dependent and independent variables indicated	Fair ---------- Good ---------- Very good ---------	1/2 1 2
Results	Data collected in table formats Graphs are available Graphs and tables are labeled well	Fair ---------- Good ---------- Very good ---------	1/2 1 2
Discussion	Chemical equations, if any Calculations done properly Discussion if the results agree with theory or hypothesis Any possible sources of errors discussed Any attempt to reduce error indicated	Fair ---------- Good ---------- Very good ---------	1/2 1 2
Over all Lab report structure	Cover page style Neatness and readability Tables and graphs have title Pages are numbered	 Good Very good	 1 2
Total points			10