IMPROVING THE IMPLEMENTATION OF PRE-LABORATORY FLOW CHARTS, COOPERATIVE LEARNING AND LABORATORY REPORT WRITING IN FIRST YEAR ORGANIC CHEMISTRY I LABORATORY CLASS

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ABSTRACT

The aim of this research was to use different assessment methods by engaging all students in pre-laboratory flow charts with check lists by taking into account rather than giving a mark for attendance for their presence, based on principles of cooperative learning method by forming groups, promoting positive interdependence among individuals, providing individual accountability and helping students to develop team work skills and lastly the post laboratory reports evaluation and presentation on selected criteria's summarizes the research base that attest to the effectiveness of methods and improvement of cooperative learning in practical organic chemistry I class. *[African Journal of Chemical Education—AJCE 6(1), January 2016]*

INTRODUCTION

Many students who have worked in a team in a laboratory- or project-based course do not have fond memories of the experience. Some recall one or two team members doing all the work and the others simply going along for the ride but getting the same grade. Others remember dominant students, whose intense desire for a good grade led them to stifle their team mates' efforts to contribute. Still others recall arrangements in which the work was divided up and the completed parts were stapled together and turned in, with each team member knowing little or nothing about what any of the others did. Whatever else these students learned from their team experiences, they learned to avoid team projects whenever possible [1].

Laboratory work is an established part of courses in chemistry in higher education. The original reasons for its development lay in the need to produce skilled technicians for industry and highly competent workers for research laboratories and others [2, 3]. Today, the aims may be different, in that many chemistry first degree graduates are not employed as bench chemists in industry and the needs of research have inevitably become much more specialized as chemical knowledge has expanded [4].

Students typically arrive at the laboratory to carry out an experiment without a very clear idea of the practical techniques they will be using, the skills they will need, or the chemistry which underlies the practical. It is usually only after the laboratory, during a write up, that students will generally start to work out what it was they had been doing all day. This is obviously an unsatisfactory experience and students will clearly get much more from their laboratory work if they know what they are doing beforehand. Pre-laboratory preparation is the key to achieving this and the laboratory skills philosophy has therefore been to shift the balance of work outside the laboratory to before rather than after the practical class so that students are much better informed and more confident. As part of their pre-laboratory work, students are required to work through some background information about the experiment including sets of multiple choice and multiple completion tests which also provide instant feedback on any wrong answers.

Very frequently, it is asserted that chemistry is a practical subject and this is assumed, to offer adequate justification for the presence of laboratory work. Thus, the development of experimental skills among the students is often a suggested justification. Nonetheless, this argument needs to be questioned to justify the position or role of the laboratory in the field of chemistry education [5].

Cooperative learning is an approach to group work that minimizes the occurrence of those unpleasant situations and maximizes the learning and satisfaction that result from working on a high-performance team. A large and rapidly growing body of research confirms the effectiveness of cooperative learning in higher education [6]. Relative to students taught traditionally, i.e. with instructor-centered lectures, individual assignments, and competitive grading cooperatively taught students tend to exhibit higher academic achievement, greater persistence through graduation, better high-level reasoning and critical thinking skills, deeper understanding of learned material, greater time on task and less disruptive behavior in class, lower levels of anxiety and stress, greater intrinsic motivation to learn and achieve, greater ability to view situations from others' perspectives, more positive and supportive relationships with peers, more positive attitudes toward subject areas, and higher self-esteem. Another nontrivial benefit for instructors is that when assignments are done cooperatively, the number of papers to grade decreases by a factor of three or four [7]. The proven benefits of cooperative learning notwithstanding, instructors who attempt it frequently encounter resistance and sometimes open hostility from the students. Bright students complain about begin held back by their slower teammates; weak or unassertive students complain about being discounted or ignored in group sessions; and resentments build when some team members fail to pull their weight. Knowledgeable and patient instructors find ways to deal with these problems, but others become discouraged and revert to the traditional teacher-centered instructional paradigm, which is a loss both for them and for their students [8].

The pre-laboratory instructions have been employed for physics students and cooperative learning styles and laboratory reports also applied on different disciplines. Therefore, this paper describes pre-laboratory flow charts instructions, cooperative learning methods that have been proven effective in a variety of instructional settings and post laboratory report writing with presentation. We then suggested ways to maximize the benefits of the approach and to deal with the difficulties that may arise when pre-laboratory flow charts are drawn for students to have awareness on the experiments, cooperative learning methods to build a team work spirit of students and managing ability on practical organic chemistry I with report writing for to develop the scientific writing skills for their further carrier.

METHODOLOGY

Population was selected from Haramaya University, Chemistry Department year one practical organic chemistry I class students. The study survey designed to use different assessment techniques in practical organic chemistry I laboratory class based on year one chemistry 2012 batch. The design is intend to assess the usefulness of pre-laboratory flow charts and engaging all students in laboratory work, effectiveness of group formation based on cooperative learning elements. In addition to this research designed for the evaluation of post-laboratory report writing and presentation of the selected experiments as well as changing the attitude of fresh students for their further carrier in creating self-confident professionals of chemistry.

Sampling Techniques

In this study all students of year one practical organic chemistry I class students were participated on this experiment and their group organization were taken randomly.

Data Collection Instruments

The students were used pre-laboratory flow charts, laboratory reports with presentation on the selected experiments and post survey as the main instruments for collecting data. In order to gather information and facts through this instrument, check lists, criteria for report writing and presentation were prepared. Post survey questions were developed and distributed to all year one practical organic chemistry I class students.

Method of Data Analysis

In this study, qualitative data collection techniques were used as primary research methods. However, in order to organize, classify and analyze the gathered information, the researchers used mean, average and percentage statistics as a way to measure the students' level of improvement practical skills through the use of flow chart check lists, criteria for report writing and presentation as well as questionnaire strategies. The main sources of information were the daily observation laboratory assistances and students during the practical organic chemistry I class. The "face to face" interactions gave us the opportunity to deepen into their experiences, thoughts and feelings.

RESULTS AND DISCUSSION

Action Plan, Implementation and Action Evaluation

A. Action Plan

Most of the students were not come up with pre-laboratory activities which make them aware of what will be the experiment rather they say that, “Mr. X will come up with pre lab works like flow charts and home activities before laboratory and perform the tasks as usual”. And not engagement of all group members to perform the laboratory activities rather two or three (2 or 3) individuals do the activity.

In addition, when students self-selected in to teams, the best students tend to cluster, leaving the weak ones to shift for themselves, and friends cluster, leaving some students out of groups and excluding others from cliques within groups.

When laboratory assistances form a group based on their alphabetical order of names, non-heterogonous group formed. Moreover, when graduates go to work in industry or business, they will be required to work in teams and will have no voice in the team formation, and their job performance evaluation will depend as much on their ability to work with their team mates as on their technical skills.

Typically each laboratory completed requires a report; this weekly report submission places an emphasis on submission at any cost rather its accuracy and the non-copy of other groups, consequently a trend of quantity rather than quality is observed. Therefore, criteria’s must be selected and introduced to students at the beginning of the laboratory.

B. Implementation

Proposed Action for Pre-Laboratory Flow Charts

Students worked in teams of five or six on activities that involved laboratory works and most activities focused on a many practical skills and could be completed in 3 hours session for a single experiment is common in Haramaya university chemistry department due to the large number of students, lack of resources like chemicals, instruments and work places. However, it is possible to reduce this problem by engaging all students to the pre-laboratory flow charts. Therefore, the best pre-laboratory flow charts each group members were selected by respective group members and submitted for laboratory assistances. Then the best pre-laboratory flow charts of each group were evaluated and the results were posted to all students to create a competitive spirit among individuals and groups.

Cooperative Learning

Students working alone may tend to delay completing assignments or skip them altogether, but when they know that others are counting on them, they are motivated to do the work in a timely manner [9].

Individual student performance was superior when cooperative methods were used as compared with competitive or individualistic methods. The performance outcomes measured include knowledge acquisition, retention, accuracy, creativity in problem solving, and higher-level reasoning. According to the Johnson & Johnson model, cooperative learning is instruction that involves students working in teams to accomplish a common goal, under conditions that include the following elements [10].

Laboratory Assistances were form teams based on their semester average grade rather than permitting students to choose their own team mates. The criteria were selected and used for team or group formation for doing experiments [10].

When students work in pairs, the diversity of ideas and approaches that leads to many of the benefits of cooperative learning may be lacking. In teams of 8 or more, some students are likely to be inactive unless the tasks have distinct and well-defined roles for each team member. The unfairness of forming a group with only weak students is obvious, but groups with only strong students are equally undesirable. The members of such teams are likely to divide up the homework and communicate only cursorily with one another, avoiding the interactions that lead to most of the proven benefits of cooperative learning. In heterogeneous groups, the weaker students gain from seeing how better students approach problems, and the stronger students gain a deeper understanding of the subject by teaching it to others.

Assigning different roles to team members (as coordinator, recorder, checker, group process monitor), rotating the roles periodically or for each experiments. The coordinator reminds team members of when and where they should meet and keeps everyone on task during team meetings; the recorder prepares the final solution to be turned in; the checker double-checks the solution before it is handed in and makes sure the assignment is turned in on time.; and the monitor checks to be sure everyone understands the solutions and the strategies used to get them. In teams of 5, the coordinator may also assume the duties of the monitor.

Give a bonus on each experiment (typically 1-2 points) to all members of teams with average test grades above rather accounting the attendance during each laboratory classes. The bonus should not be tied to each person on the team getting a certain grade, which would put too much pressure on weaker members of the team and make it impossible for teams with one very weak student to ever get the bonus. Linking the bonus to the team average grade gives all team members an incentive to get the highest grade they can and motivates the stronger students to tutors their team mates.

Give individual tests that cover all of the material on the team assignments and experiments**.** Tests or laboratory analysis questions were frequently given for individual group members. Make someone on the team (the process monitor) responsible for ensuring that everyone understands everything in the report or experiments that the team hands in**.** The monitor should also make sure everyone participates in the team deliberations and that all ideas and questions are heard. Make teams responsible for seeing that non-contributors don't get credit**.** A policy those only contributors' names should go on assignments and reports were announced at the beginning of the course, and reminders of the policy should be given to students complaining about hitchhikers on their teams. Most students are inclined to cut their teammates some slack initially, but if the hitchhikers continue to miss meetings or fail to do what they were supposed to do, eventually the responsible team members get tired of being exploited and begin to implement this policy.

Implementing Post Laboratory Report Writing and Presentation Evaluation and Checklist

All students were engaged to laboratory experiments as stated above and the post laboratory reports were submitted at the end of each experiment before starting the next experiment and evaluated based on the curricula designed. The presentation was arranged for each group and the tasks were assigned to each individual.

The checklist is designed to assist you to write a complete, professional-quality report. It will help you to ensure that all essential information is included in the appropriate place, and that the report has been prepared in the proper format. Careful use of the checklist will result in better grades. Students must submit a completed, signed checklist with each report.

The grades have been paid special attention to the checklists. The following rules were applied:

- A report submitted without a checklist attached at the front was not graded; and no credits were given for that report.
- If an item on the list is not checked, this will indicate to the grader that it has not been addressed in the report, and the appropriate number of points will be deducted.
- If an item has been checked, but has been covered only partially, or incorrectly, the report, partial credit will be given with an explanation of the omission or error.
- If an item has been checked but it has not been addressed in the report, grading was discontinued, and no credit will be given for the report, on grounds of unethical behavior.

C. Action Evaluation

The collected data from each of the above procedure were evaluated as to prove the effectiveness of pre-laboratory flow charts, post implementation questionnaire and report writing with presentation on the achievement of year one practical organic chemistry I students. The results were tabulated and analyzed as follows.

Table 1: *Pre-laboratory flow charts check lists and evaluations 2.0% for each experiment.*

Group No	Exp’t No 1	Exp’t No 2	Exp’t No 3	Exp’t No 4	Exp’t No 5	Exp’t No 6	Exp’t No 7	Exp’t No 8	Exp’t No 9	Exp’t No 10	Total 10%
1	0.25	0.5	0.75	1	0.5	1	1	1	1	1	8
2	0	0.5	0.75	1	0.5	1	0.75	1	1	1	7.5
3	0.25	0	0.5	0.5	1	0.5	1	1	1	1	6.75
4	0	0.75	0.75	1	0.75	1	0.75	1	1	1	8
5	0	0	0.75	1	0.75	1	1	1	1	1	7.5
6	0	0.75	1	0.5	0.5	1	1	1	1	1	7.75
7	0,25	0.75	0.75	1	1	0.75	1	1	1	1	8.25
8	0	0	0.5	1	0.75	1	1	1	1	1	7.25
9	0.25	0.75	1	1	0.75	0.5	1	1	1	1	8.25
10	0	0.75	1	1	1	0.75	1	1	1	1	8.5

Exp’t: Experiment

According to the data tabulated above, the performance of each groups increased. However, this increment comes from the competition among individuals in respective group members and in the groups. The competitions in each group members were formed by selecting the best flow chart from each group members to compete with others and competition among the groups were formed by showing their result on notice board arranged from the higher to lower. The low achievers were ashamed with their mark and planned to become the first for the next work. Even if some group members were not to bring the pre-laboratory activities for experiment number one and two, then they believed that not doing the pre-laboratory flow charts may affect their grade. Taking an attendance for the students presence were common earlier, but now, they exposed to do pre-laboratory flow charts which make them aware of what will be done in the laboratory and evaluated by their flow chart diagrams 10% instead of accounting 10% for their presence. Generally, this way of evaluation was considered as very useful for practical organic chemistry courses.

Table 2**:** *Post implementation (action Evaluation) questionnaire responded by students*

No	Items	No of respondents		% of Respondents	
		Yes	No	Yes	No
1	Do you participate in doing experiments during organic laboratory regularly?	50	0	100%	0
2	Have you brought pre lab activities and flow charts to the class before starting experiments?	50	0	100%	0
3	Do you contribute in laboratory report writing?	50	0	100%	0
4	Are you interested in organic laboratory class with new approach of cooperative learning?	47	3	94%	6%
5	Do all your group members engaged in all experiments?	50	0	100%	0
6	Did your group member rotate the responsibility for each experiment which assigned in different roles to team members (as coordinator, recorder, checker, group process monitor)?	48	2	96%	4%
	Total number of students responded for pre implementation questionnaire	50			

According to the response of students about cooperative learning, six (6) post implementation questions which were similar to pre implementation questions were considered and administered for students. The response of each items of questions were discussed as follows.

As shown in table 2 items number 1 and 2, all of the students were participated in doing experiments during laboratory regularly and bring pre laboratory activities and flow charts before starting experiments.

Among 50 students, 94% of them were interested in practical organic chemistry with the new approach of cooperative learning and the rest students still not interested. In addition to this, all of them were contribute in laboratory report writing and engaged in all experiments. But, 4% of the total students were not rotate the roles to be responsible for each experiments which assigned in different roles to their team members as coordinator, monitor, checker and recorder one role for a single experiment.

Table 3**:** *Laboratory report evaluation and presentation results 5% for each experiment*

Group No	Exp't No 1	Exp't No 2	Exp't No 3	Exp't No 4	Exp't No 5	Exp't No 6	Exp't No 7	Exp't No 8	Exp't No 9	Exp't No 10	Total 50%
1	3.5	4	5	4	4.5	3.5	5	5	4.5	3.5	42.5
2	4	5	4	5	4	4	5	4	5	4	44
3	3	5	4	5	4	3	5	3	5	3	40
4	4	4	4	5	4	4	5	4	4	4	42
5	4.5	3	4	5	4	5	4	5	4	5	43.5
6	3	4.5	3	5	3	5	4	5	3	5	40.5
7	5	3	4	4	4	4	4	4	4	4	40
8	4	3	4.5	3	4.5	5	4.5	5	4.5	3	41
9	4	3	4	5	3	5	3.5	5	4	5	41.5
10	3.5	4.5	3.5	5	5	5	5	4.5	5	4.5	45.5

As shown in the above table, the laboratory reports were evaluated based on criteria which indicated in appendix-D and from the evaluated results, some groups like group number 10, 2, 5, and others may have the possibility in falling "A'' grade range. But this may happen if they answer the final examination which will be accounted out of 40% relatively.

CONCLUSIONS

Students typically arrive at the laboratory to carry out an experiment without a very clear idea of the practical techniques they were using in the laboratory, the practical skills they will need, or the chemistry which underlies the practical. It is usually only after the laboratory, during a write up, that students were generally start to work out what it was they had been doing all day. This is obviously an unsatisfactory experience and students were clearly got much more from their laboratory work if they know what they were doing beforehand. Pre-laboratory preparation was the key to achieving this therefore been to shift the balance of work outside the laboratory to before rather than after the practical class so that students were much better informed and more confident.

It is believed that the pre-laboratory flow charts, cooperative learning and post laboratory report writing method pedagogies could strongly impact on practical organic chemistry I classes by providing students with both a real-world context for the chemical principles and a more accurate portrayal of the way that modern science is practiced. The collaborative nature of the pre-laboratory flow charts, cooperative learning and post laboratory report writing methods creates a better working atmosphere for all students in this action research. We have also found that the pre-laboratory flow charts, cooperative learning and post laboratory report writing methods bring students from a variety of backgrounds to the same level of class involvement, which is especially important in classes that include both students who have taken advanced placement chemistry and those who have not taken chemistry previously. Most importantly, by simulating the experiments to the scientific problem-solving process in the classroom, students gain an understanding of what it means to think like a chemist and gain confidence in their ability to carry out those thought processes or reactions and products. The cooperative learning was an ideal pedagogy for demonstrating to students the interaction of science, technology, and society, and it allows them to develop a sense of the social impact of science-related decisions.

Thus, cooperative learning refers to work done by student teams producing a product of some sort such as a laboratory report, or the design of a product or a process, under conditions that satisfy five criteria: (1) positive interdependence, (2) individual accountability, (3) face-to face interaction for at least part of the work, (4) appropriate use of interpersonal skills, and (5) regular self-assessment of team functioning [10]. Extensive research has shown that relative to traditional individual and competitive modes of instruction, properly implemented cooperative learning leads to greater learning and superior development of communication and teamwork skills (e.g. leadership, project management, and conflict resolution skills). The technique has been used with considerable success in all scientific disciplines, including chemistry.

Most importantly, instructors or laboratory technicians who are successful in using cooperative learning in their classes will have the satisfaction of knowing that they have significantly helped prepare their students for their professional careers. No one said anything negative about group work or cooperative learning; although three respondents indicated that they disliked it. Practitioners don’t guarantee a retrospective evaluation this positive to everyone who uses cooperative learning, but we believe the possibility of it makes the effort worthwhile.

The post-laboratory report writing also needs careful thought. Imaginative post-laboratory exercises were used. These allowed students opportunities to apply the ideas they had learned, as well as offering some insights into their understanding. A range of ingenious post-laboratory exercises in practical organic chemistry I class were considered very valuable when the students report evaluated.

Using different active learning methods especially pre-laboratory flow chart evaluation and check lists, cooperative learning and post laboratory report writing evaluation and presentations in practical organic chemistry I class and other laboratory classes are possible. By using these methods we have seen astonishing results in organic chemistry I laboratory class and some of the results are obtained by changing the older mode of teaching to modern active learning methods. Furthermore, the students who were taught in the active- learning mode did much better in practical organic chemistry I laboratory sections of this course, in addition to its academic advantages, active learning has been shown to produce numerous social and psychological benefits observed students attitude towards the subject. As a recent review of research on cooperative learning found that it boosts development of critical-thinking skills and fosters social interdependence and support among students. Therefore, if any laboratory technicians or laboratory teachers apply this basic work, they will develop a well-mannered chemist professional.

University faculties sometimes feel that although active learning may work in some fields, it probably would not work in their field. The fact that practical organic chemistry could successfully employ the techniques described in this paper speaks well for the universality of this teaching pedagogy.

This paper makes a practical application for the students' achievement and performances. Generally, this paper confirms that practical organic chemistry I class students obtained particularly:-

- ✓ Skills relating to learning making chemistry real, illustrating ideas, empirical testing ideas, teaching new ideas,
- ✓ Practical skills handling equipment and chemicals safely, measuring and observing carefully,

- ✓ Scientific skills learning skills of deduction and interpretation, seeing a science at work, devising experiments, and
- ✓ General skills team working, reporting, presenting and discussing, developing ways to solve problems.

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APPENDICES

Appendix A: Pilot test questionnaire response of students

No	Items	No of respondents	% of respondents
1. 1.	Do you participate in doing experiments during organic laboratory regularly?		
	A. Yes	10	20%
	B. No	40	80%
2. 2.	Do you contribute in laboratory report writing?		
	A. Yes	19	38%
	B. No	31	62%
3. 3.	Have you brought pre-laboratory activities and flow charts to the class before starting experiments?		
	A. Yes	6	12%
	B. No	44	88%
4. 4.	Who is responsible in forming groups for laboratory work?		
	A. Laboratory assistances based on alphabetical order	26	52%
	B. Students based on their team mate	24	48%
Total number of students responded for pre-implementation questionnaire		50	

Appendix B: Post implementation questionnaire used for action evaluation

No	Items	No of respondents		% of Respondents	
		Yes	No	Yes	No
1	Do you participate in doing experiments during organic laboratory regularly?	50	0	100%	0
2	Have you brought pre lab activities and flow charts to the class before starting experiments?	50	0	100%	0
3	Do you contribute in laboratory report writing?	50	0	100%	0
4	Are you interested in organic laboratory class with new approach of cooperative learning?	47	3	94%	6%
5	Do all your group members engaged in all experiments?	50	0	100%	0
6	Did your group member rotate the responsibility for each experiment which assigned in different roles to team members (as coordinator, recorder, checker, group process monitor)?	48	2	96%	4%
Total number of students responded for pre implementation questionnaire		50			

Appendix C: Flow charts sample