Using Collaborative Formative Assessments in Enhancing Students' Understanding of Concepts in Grade 9 Electron Configuration

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ABSTRACT This action research focuses on the use of collaborative formative assessment in learning about electron configuration in a Grade 9 science classroom. It aimed to examine how students do formative assessments as they collaborate in groups and to determine if the use of collaborative formative assessment tasks promotes learning. After each lesson, the students were grouped and were given teacher-made formative assessment tasks on the topics quantum numbers and electron configuration to accomplish. Observations, interviews, worksheets, survey, and an objective performance test were used to gather data from the students. The findings indicate that the students like the use of collaborative formative assessment and central to their experience is the presence of peer feedback and support which they reported were useful to promote learning. While the findings also indicate that some students experience social loafing during collaborative work, the use of collaborative formative assessment encouraged sharing of ideas and immediate feedback. Based on the findings, the researchers recommend the use of collaborative formative assessments as an innovative approach of assessment that can promote conceptual understanding in Grade 9 Science classrooms.

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Introduction

As the K to 12 curriculum unfolds, the grading system in the Enhanced Basic Education Program of the Department of Education is revised. From the Knowledge-Process/ Skill-Understanding-Performance/Product (KPUP) model, classroom assessment has now shifted to the use of written works, quarterly assessments, and performance tasks. The Department of Education (DepEd) Order Number 8, Series of 2015 emphasize that learners should be assessed through various processes appropriate to and congruent with learning competencies defined in the K to 12 curriculum. The same DepEd order highlighted that these processes may be used for both formative and summative assessment and that students may be assessed individually or collaboratively. The DepEd Order No.8 Series of 2015 also indicates that collaborative assessment or peer assessment allows students to support one another's learning through discussions, role-playing, games, and other group activities that may be used as performance-based formative assessment. These changes in the way assessment of learning is done in classrooms call for the adoption of more innovative approaches or strategies in both formative and summative assessments of students' learning.

To address the need to innovate in our ways of assessing our students, the researchers planned and implemented an action research on the use of collaborative formative assessment in a Grade 9 science classroom. As teachers, the researchers admit that they have not fully made use of assessment tasks for learning and have not tried collaboration in formative assessment tasks. The

researchers also believe that many teachers do not practice the use of collaborative formative assessment. Hence, the researchers believe that conducting an action research on collaborative formative assessment would be an important step in examining its usefulness in teaching and learning in the classroom and could help the researchers gain insights on how they and other teachers can improve their assessment and instructional practices.

Heritage (2011) explains that formative assessment is not a kind of test. When implemented effectively, formative assessment practices can have powerful effects on learning. Teachers are involved in making adjustments to instruction based on evidence collected through formative assessment and by providing students with feedback that helps them advance their learning. Formative assessment can be done through self- and peer-assessment. Students give feedbacks to their classmates that are intended to be constructive and promote progress (Heritage, 2011).These feedback help learners to learn better and also teachers can improve their instruction.

Collaboration is an interactive process that engages two or more participants who work together to achieve outcomes more effectively and more efficiently. According to Swan et al. (2006), collaborative learning, when given importance, will lead to more success. Gokhale (1995) found that collaborative learning enhances critical thinking through discussion, clarification of ideas, and evaluation of others' ideas. Collaborative learning activities can elicit conceptual understanding by allowing students to explain, elaborate, and reorganize their knowledge. Because the students are in groups, social interaction promotes comprehension of conceptual understanding by letting the students elaborate their explanations. Discussions produce conceptual understanding by sharing (Van Boxtel et al., 2000).

When formative assessment is used with collaborative learning, it enhances the critical skills of the students (Gulikers et al., 2013). Hargreaves (2007) studied the validity of collaborative assessments and she noted the following: the assessment for learning actually leads to further learning of a kind that is consistent with other social values; the form and content of the assessment for learning reflects and encourages valuable learning; and the assessment is an inquiry rather than a measurement of classroom conditions that are conducive for valuable learning.

As teachers who regularly conduct formative assessments in order to gauge students' learning, the researchers designed an action research plan to examine the use of collaborative formative assessment in a Grade 9 science classroom which the main researcher is handling. A plan on how the collaborative formative assessment would be used in a Grade 9 science class was jointly crafted by the researchers in order to examine how students perform informative assessments as they collaborate in groups and how the use of collaborative assessment promotes learning.

This action research mainly describes the process of collaborative formative assessments among students in a science classroom, specifically on the topics quantum numbers and electron configuration. It aimed to explore students' views on collaboration, to observe what happens during collaborative work as a way of assessment in the classroom, and to explore how collaborative formative assessments affect students' understanding of concepts on electron configuration. This action research was deemed important as it may provide information and insights on how students collaborate in assessment and how such collaboration contributes to learning. This is especially important as collaboration is one of the 21st century learning skills that students' must acquire. The action research may also provide

insights on students' views on doing formative assessments while being in groups and on how collaborative formative assessments may give feedback to teachers on mastered and least mastered skills on a particular topic which can serve as basis to improve instruction and assessment practices. The researchers hoped that conducting this action research could pave the way for more innovations in conducting assessment in the classrooms.

Methodology

As an action research, the study is descriptive in nature and gathered data from multiple sources. Worksheets and interviews were used to gauge the extent of collaboration and if Grade 9 students understood chemistry concepts using collaborative formative assessment. Observations and further interviews were conducted to identify problems and assess how collaboration was done, how students contribute in collaborations, and how students understand concepts in electron configuration. Students' performance in an objective performance test was also gathered.

The action research plan was implemented by the main researcher in one of the Grade 9 science classes he was handling. Before the implementation of the action research, approvals were sought from the department head, the 38 student participants, and their parents. Orientation about the study and about collaborative formative assessment was conducted. Lessons on quantum numbers (prerequisite), electron configuration, and orbital diagrams were executed within two weeks using a mixture of lecture, demonstration, and reading activities. For each lesson, collaborative formative assessment tasks were given after the lesson proper. For each assessment task, the students were grouped and their conceptual understanding was assessed using related formative assessment tasks.

While the collaborative assessment tasks were being done, observations were made to find out how the students participate in the collaborative tasks. The extent of their collaboration and participation was noted. A set of rubrics was used to assess the extent of student collaboration. Each group also wrote down their learning, reflections, and accomplishments after each collaborative formative assessment. The students' data on their conceptual understanding of electron configuration were collected through worksheets. These worksheets were given after a lesson on concepts of quantum numbers and electron configuration.

In addition, interviews with 10 randomly selected students were conducted to validate the results of the observations made. Sample questions are: "Describe how you did the task at hand with your partner or groupmates."; "Did you understand the lesson? How did you understand the lesson?"; "As a learning experience, how would you evaluate the use of collaborative formative assessments?"; and "What, if any, aspects of your own behavior do you need to change to be more effective as group member/partner?" The students' perception on collaborative learning was also assessed by adopting the questionnaire developed by Brown (2015).

Lastly, a 20-item paper-and-pencil performance test on concepts in electron configuration was administered to the students after the two-week intervention to objectively assess and score the students' conceptual understanding. The worksheets and objective test on quantum numbers and electron configuration used in the study were validated by the Chemistry teachers in Grade 9. Descriptive statistics and content analysis were performed to analyze quantitative and qualitative data respectively.

Results and Discussion

Teacher's Observation

In order to explore how collaborative formative assessment affects students' understanding of the concepts of collaboration, observations were done on each group. Groups of four to five students were created. Each group was instructed to answer the worksheets which contain both learning tasks and formative assessment tasks. There was no orientation on who would be the leader. The instruction was for the members to answer the given worksheet as a group.

After instructions were given, it was observed that the groups appointed no leader. The students first worked in pairs, some individually. Then after answering easy items in the worksheet, the students in the group began to share or ask questions from their group mates. The other groupmates responded to the questions even though they were not sure of their own answers. Sharing of answers started to flow from pairs of students towards the whole group.

As observed, collaboration in answering formative assessment tasks started through pairing. Pairing was observed in students that were adjacent or "near" to each other. Collaboration was seen in each pairs as they answer the worksheets. Since electron configuration needs conceptual understanding and mathematical skill, when a student lacks that particular skill or concept, he/she tended to look for support. The other student supports the student who lacks the skill. The students began to share or help each other out. This was evident even though a leader was not appointed in the group.

After sharing in pairs, the discussion extended towards the group. This may be due to the possibility that students in pairs have obtained the necessary skills and

concepts needed to answer the formative assessment tasks. If there were wrong answers or if a pair was not sure of their answers, other members voiced their disagreement and corrected the mistake of the other pairs. Feedback is evident as the students worked on their assessment tasks. From the continuous observation of the various groups in the classroom as they collaborated in completing the worksheets, it was observed that the students learn from each other as they attempt to come up with a group answer or consensus. This observation is supported by the data from the interviews where some students reported that they learned more in groups rather than individually.

As observed by the main researcher, the major factor that contributed to the students' learning in collaborative work is feedback. For instance, when a member of a group shared an answer that was in correct, the other members point and correct the mistake. When a mistake was corrected, learning was achieved. On the other hand, when a student shares a correct concept, the other members of the group also learned. This was even more emphasized as the students explain their answers or conceptual understanding to the group.

The teacher also observed that some members in a group is not actively participating. This observation is called social loafing. Some students tend to exert less effort in a group than when working alone. Rich et.al. (2014) provided some strategies in reducing social loafing in group projects. For instance, it is suggested that teachers must prepare a task that is challenging and motivating to all students while providing individual performance evaluation, emphasizing valuable individual contributions, seeing that groups are cohesive, and providing peer evaluations (Rich et al., 2014). As the class moves on from one topic to another, social loafing was managed by giving the students challenging problems regarding quantum numbers and electron configuration and through the introduction of peer evaluation.

Students' Learning

Collaborative formative assessment tasks can promote conceptual understanding of electron configuration. This is evident in the students' worksheets and from the students' responses in the interviews. As evidenced by the completed worksheets and as observed by the researchers, the students who participated in the action research were able to learn the skills needed for writing the set of quantum numbers and analyzing the written sets required for understanding electron configuration, as well as writing electron configuration in many forms.

Another evidence of students' understanding of the concepts in electron configuration are the results of the objective performance test. Results indicate a performance mean score of 13.3974 (SD= 1.4244) which is higher than the midpoint value of the 20-item post-test. Moreover, all the students earned passing rating. These scores indicate that the students attained conceptual understanding of the lessons in both quantum numbers and electron configuration because the mean score is above the passing rate of 50%.

Collaboration in using these formative assessments was important to facilitate the learning of the lessons/topics. Valid formative assessments with collaboration made the students learn the concepts on how to write and interpret electron configurations. As reported by the students during the interviews, they understood the lesson because the group helped in explaining the concepts and developing the skill in writing electron configurations through sharing and giving feedback while doing collaborative formative assessments.

During the interviews, the students described how they have done the formative assessments by collaboration and how they have learned a lesson the through their group. As summarized in Table 1, the students reported that they

understood the lessons through the help of their group mates. According to them, their group mates taught and explained to them the concepts clearly when they did not know or understand how to do the task. When asked why they liked collaborative work, most students responded that their experience of sharing, teamwork, and feedback were the main reasons. Nevertheless, while the findings in the interviews show that most of the students liked doing collaborative formative assessments, there were students who reported their preference for individual work.

As seen in Table 1, the students also reported that they liked doing formative assessment tasks in groups rather than individually because of the opportunity for giving and receiving feedback. Students in groups receive immediate feedback, on whether their answer is correct or wrong. If it was incorrect, the student could correct his or her answer based on the feedback from his or her groupmates. If the answer is already correct, suggestions were given to better improve the answers or provide an easier way of solving problems. These findings are consistent with the students' evaluation of collaborative learning (see Table 2) where many students have indicated agreement on the role of feedbacks in their learning.

Table 1. Sample Interview Questions and Verbatim Responses of te Students

Sample Questions	Sample Student Responses
Describe how you performed the task at hand with your partner or with your groupmates.	• Sharing the knowledge and a way for each to learn • We have our own task and then work as one • In group work, our task was done quickly • We do team work • Focusing on the topic (task) and serious in answering • By analyzing the topic (task) and collect more information about the topic

	• By giving each other a task to accomplish • We collect the information about the task and then combine all of it then distribute to every member of the group • We collaborate in doing the tasks • I do my task first then share it with another member to know if we have same answers then share it with the group • We help each other to know if we answered it correctly
When do you learn best, in a group or individually? Why?	In a group because… • If I don't know a concept or what to do or even how to do a task, I have my group mates to help me understand • My group mates teach me when I do not know the topic • I learn more when they share what they know • We learn when we discuss • If I don't know the answer, I ask them • We share our ideas • It finishes the task quicker Individually because… • I learn best by my own • It makes me focus on my own and better process the task at hand
How effective was the group in answering questions given to you about a certain topic?	Very effective because… • We learn by helping each other to do the task • We are sharing ideas and training the skills needed as one group • We work as a team • I can learn the best way how to solve a problem • It makes working on the task quicker • We share our knowledge to them and share their knowledge to us Effective because… • I learn when my group mates help me and when, in turn, I help my group mates

	• Because I get advises when I do not arrive correctly with my answers • Because I can now share my answers even if they are wrong so I learn unlike when I am alone, if I have confusions or clarifications, I just leave it to myself • Because groupmates can help me especially when I am not listening at that time
Did group work help you in knowing better the concepts or things that you did not know or understand?	Yes because… • When I have concepts that I don't understand, I have my groupmates to help me understand • My groupmates share what they know to the group thus learning a lot • My groupmate teaches me the skills and concepts needed • First, I don't like group work but I realized that I learn more in groups

Table 2. Frequency of the responses of the students on their perceptions about collaborative learning

	SA	**A**	**D**	**SD**
1. Collaborative work helped me better in understanding the concepts.	24	14	0	0
2. Collaborative work helped me foster exchange of knowledge, information and experience with my group mates.	16	22	0	0
3. Collaborative work made problem-solving easier.	6	19	8	5
4. Collaborative work stimulated my critical thinking.	11	21	6	0
5. Collaborative work gave me a more relaxed atmosphere.	6	21	11	0
6. I received useful/helpful feedback from my groupmates.	19	19	0	0

7. The concepts were clarified with the help of my groupmates.	19	16	3	0
8. Our tasks were focused on collective efforts rather than on individual effort.	15	22	1	0
9. I have greater responsibility – for myself and the group.	9	24	3	1
10. I was enabled to help slow learners in the group.	10	26	1	1
11. My communication skill was enhanced.	12	24	1	1
12. I have improved my performance in class.	11	26	0	1
13. I actively participated in the teaching/learning process.	12	25	1	0
14. My groupmates actively participated in the teaching/ learning process.	14	24	0	0
15. Collaborative learning was an enjoyable way of learning the concepts.	21	15	0	2
16. I have made new friends.	24	14	0	0
17. Collaborative learning fosters team spirit.	18	18	2	0
18. Collaborative learning is a waste of time explaining things to others.	8	7	11	12
19. It is difficult to get members to actively participate in performing tasks.	3	11	22	2
20. Collaborative learning (pair/ group work) should be encouraged/ continued.	20	16	2	0
21. The maximum group size should be five.	17	14	5	2
N = 38				

Legend: 1= "strongly agree (SA)", 2= "agree (A)", 3= "disagree" (D), 4= "strongly disagree" (SD).

Personal Reflections

The present study is the first action research conducted by the first researcher and the first collaborative action research conducted by the other researcher. Action research is quickly becoming useful in public schools because it is a part of the evaluation process for teaching performance and reward system. The main researcher admits that this was one strong motivation in doing the research. However, after experiencing first-hand how to design and implement an action research plan, the main researcher realized that action research is necessary to efficiently solve problems that teachers usually encounter in the classroom. The experience of doing action research allowed the first research to see the value for basic education teachers to become reflective practitioners through action research. On the other hand, through this action research the other researcher was now able to fully appreciate the importance of collaborative action research.

While planning this action research, the researchers saw the value of gathering data from multiple sources rather than merely focusing on pre-test and post-test results. Interviews, teacher observation during the collaborative tasks, survey, and post-test after the lessons provided hard evidence on the usefulness of collaborative formative assessment in promoting students' learning. Indeed, the students who participated in the action research were able to learn the skills needed for writing the set of quantum numbers and analyzing the written sets required for understanding electron configuration, as well as writing electron configuration in many forms.

As we think about how science is learned, we are now also thinking about how science should be taught. Previously, we knew that collaboration is a good mechanism for learning. But now we have realized that even collaboration in formative assessment tasks can become an essential avenue for learning.

Collaboration, when combine with formative assessments can be effective in making the students learn science concepts. Formative assessments provide the mechanism for feedback that collaborative learning also provides. Integrating these two is a worthy endeavour that seems to have benefited the students in the class to which we tried the use of collaborative formative assessment.

Through this action research, we gained further insights on the value of peer feedback in learning. As used in our action research, collaborative formative assessment tasks promoted peer feedback where students learned from each other by discussing the tasks and the related concepts, correcting misconceptions, and clarifying and elaborating confusing concepts. The teacher is also able to provide the feedback to the group, further contributing to the students' understanding of the concepts needed to be learned.

Conclusion and Recommendations

This action research was conducted by the researchers to assess how collaborative formative assessment may be done in a Science classroom and to determine if such approach is effective in promoting conceptual understanding among students. The information yielded from multiple sources of data indicated that collaborative formative assessment can indeed be implemented and observed among students formed in groups and that such collaborative assessment tasks provide opportunities for learning. The researchers argue and recommend that teachers adopt the use of both collaborative and individual formative assessments, implement strategies to reduce social loafing during collaborative tasks, and examine if collaborative summative assessment would also enhance students' learning. For their own practice, the researchers commit to the use and continuous evaluation of the value and effectiveness of collaborative formative assessment tasks. The researchers hope that other teachers would follow.

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